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NEW SPECIES AND A NEW GENUS OF THE SUBFAMILY POGONINAE FROM SOUTH AUSTRALIA (COLEOPTERA: CARABIDAE)

M. BAEHR & P. HUDSON

BAEHR, M. & HUDSON, P. 2001. New species and a new genus of the subfamily Pogoninae from South Australia (Coleoptera: Carabidae). *Records of the South Australian Museum* 34(1): 1–18.

A new genus and species, *Syrdenoidius spinipes* gen. nov., sp. nov., and three new species of the genus *Pogonus* Dejean from salt lakes in South Australia are described: *Pogonus matthewsi*, *P. vicinus*, and *P. perovalis*. The first two species are closely related to *P. grossi* Moore from Lake Eyre and *P. saskiae* Baehr from Lake Gairdner and Island Lagoon and together they form a complex of four very closely related species. *Pogonus perovalis* sp. nov. is outstanding in its body shape and absence of wings, but may be remotely related to this complex. The new genus *Syrdenoidius* is highly similar in shape and structure to the Palaearctic genus *Syrdenus* Chaudoir, though it differs mainly in the asetose prosternum, the markedly spinose tibiae, the absence of wings, and a very unusual female stylomere 2. *Syrdenoidius spinipes* sp. nov. and *Pogonus perovalis* sp. nov. are outstanding in their absence of wings and loss of flying ability, attributes that are extremely rare within Pogoninae. Most of the new species were collected by excavation of their burrows on the lake surface, or by pitfall trapping.

Martin Baehr, Zoologische Staatssammlung, Münchhausenstr. 21, D–81247 München, Germany and Peter Hudson, Department of Environmental Biology, University of Adelaide, South Australia 5005, Australia. Manuscript received 24 July 2000.

Introduction

Most halophile pogonine species occupy habitats such as seashores and inland salt lakes and most are strong fliers that readily come to lights. Such habitats have been favoured collecting localities in other parts of the world for a very long time and there is a general belief that the taxonomy of the subfamily is well known. Nevertheless, several new species have been recently described throughout the world (Kryzhanovskij & Michailov 1971, Morvan 1973, Kryzhanovskij 1990, Bousquet & Laplante 1997, Baehr & Sciaky (in press), Hudson 2000). At present, there are 11 pogonine genera worldwide containing about 78 taxa. *Pogonus* s. str. is by far the most speciose genus with 49 described taxa (Lorenz 1998).

In Australia, the number of described pogonines was surprisingly low for a very long time (Chaudoir 1871, 1878; Sloane 1895). Moore (1977) described new species from Lake Eyre and since then a number of additional species have been detected and described (Baehr 1984, 1997, 1999; Moore 1991, Hudson 2000) resulting in a total of 12 species of *Pogonus* known from Australia. It is now evident that all parts of Australia suitable for pogonines are colonised by at least one or another species. The salt lake belt from interior Western Australia through the southern half of South Australia to northwestern Victoria (and probably westernmost New South Wales) is the stronghold of pogonines in Australia, with many closely related but also some unusual species occurring there.

Four new species are described herein, including a representative of an unusual new genus. Although the pogonine fauna of Australia comprises predominantly the genus *Pogonus* s. str., it is one of the most speciose in the world with high morphological diversity and includes some very strangely shaped species.

The majority of the Australian pogonines are depigmented, many are extremely elongate and depressed ('syrdeniform'), characters which are evidence of an obligatory nocturnal and at the same time psammophile life. Apart from this, very little is known about habits, ecological preferences, and life histories of most of the Australian pogonine species, since most collections have been made using light traps. It is the scope of this paper, among other things, to increase ecological information about the Australian pogonines.

The present paper was prepared when the senior author (MB) worked through the unidentified carabid material in the South Australian Museum, Adelaide, and separated a number of pogonine specimens that turned out to belong to undescribed species. They had been mostly collected by the junior author (PH) during his ample collecting work on salt lakes throughout South Australia. Personal contact between MB and PH during MB's stay at the Museum revealed that PH had a number of additional, freshly caught specimens that were subsequently sent to MB for identification. Since PH has collected many taxa using pitfall traps and by excavation of burrows, both authors agreed to collaborate in a joint paper, with MB mainly responsible for the taxonomic section, and PH for the ecological part. Authorship of the new taxa is in joint names. Some records of known species from the SAMA collection and those made by MB during a recent collecting trip through northwestern Victoria and southern South Australia are also included, in cases where they enlarge the known range or add any other information.

Measurements

Measurements were taken using a stereo microscope with an ocular micrometer. Length has been measured from apical margin of labrum to apex of elytra; measurements, therefore, may slightly differ from those of other authors. Length of pronotum was taken at the longest distance (which is not always along midline!), and width between the posterior lateral angles.

Location Of Material

The holotypes of the new species are located in the South Australian Museum, Adelaide (SAMA), paratypes of all species are kept in the working collection of the senior author (CBM) at the Zoologische Staatssammlung München. Paratypes of *Syrdenoidius spinipes* are also kept in the Australian National Insect Collection, Canberra (ANIC).

Taxonomic Principles

Whereas one of the three new taxa of the genus *Pogonus* is very specialised in shape and structure and certainly merits full specific status, two taxa belong to a group of depigmented, elongate, depressed, syrdeniform species that so far include *Pogonus grossi* Moore and *P. saskiae* Baehr from saline inland habitats in South Australia. The four taxa now known to exist in this group are very similar and certainly they are closely related. They have been collected at four different localities throughout the salt lake belt of South Australia, and could be either subspecies of one widespread species, or closely related species. We have decided to rank them as species rather than subspecies for two reasons. Firstly there appear to be consistent, though minor differences, between them (see Tables 1 and 2). Secondly there are heuristic

TABLE 1. Some distinguishing characters within the *Pogonus grossi*-group

	grossi **(L. Eyre)**	***vicinus*** **(L. Frome)**	***matthewsi*** **(Pernatty Lag.)**	***saskiae*** **(Island Lag.)**
body size	large	large	large	small
pronotum	wide	wide	wide	narrow
basal angle	slightly excised	not excised	not excised	excised
basal angle	not dentiform	dentiform	dentiform	not dentiform
lateral margin	evenly convex	rather straight anteriorly convex	evenly convex	evenly convex
lateral margin	widest behind anterior third	widest in front of anterior third	widest at anterior third	widest at anterior third
elytra	rather depressed	rather depressed	convex	depressed
intervals	slightly convex	slightly convex	strongly convex	slightly convex
striae	distinctly punctate	barely punctate	distinctly punctate	distinctly punctate
striae	rather deeply impressed	rather shallow	deeply impressed	rather deeply impressed
microreticulation	distinct	distinct	very distinct	distinct

TABLE 2. Summary of measurements and ratios for all species of the *Pogonus grossi*-group. For better recognition of the species the measurements and ratios for all species of the *P. grossi*-group are compiled in the following table.

	body length (mm)	ratio width/length pronotum	ratio width base/apex pronotum	ratio width pronotum/head	ratio length/width elytra	ratio width elytra/pronotum
grossi	5.2–6.4	1.18–1.21	0.91–0.93	1.13–1.15	1.85–1.91	1.27–1.35
vicinus	5.1–6.0	1.13–1.16	0.98–1.01	1.16–1.21	1.72–1.77	1.30–1.34
matthewsi	5.6–6.2	1.15–1.17	0.96–1.02	1.12–1.16	1.86–1.90	1.26–1.28
*saskiae**	4.65–4.90(4.15)	1.07–1.11(1.21)	0.87–0.88(0.85)	1.03–1.10(1.12)	1.96–1.98(1.90)	1.29–1.40

* In *Pogonus saskiae* Baehr one extraordinary small specimen has some rather different proportions of pronotum and elytra (see Baehr 1997) that are added in brackets.

reasons for doing so since definition of subspecies is more difficult than that of species and would require more information about gene flow or hybrid zones. Further investigations should show which concept is better applicable to this difficult group.

Taxonomy

There is no need for an extensive characterization of the subfamily Pogoninae (or tribe Pogonini, according to the preferred system). A list of synonymies including the most important citations, and an extensive diagnosis of the subfamily was recently given by Bousquet and Laplante (1997) that should be used by readers who want to receive more general information about the group. A summary of the presently known genera and species has been recently provided by Lorenz (1998). More information about the Australian *Pogonus* species can be obtained from Moore (1977), and the subsequent descriptions of additional species by Moore (1991), Baehr (1984, 1997, 1999), and Hudson (2000).

Additional Records Of Described Species

Pogonus grossi Moore

Moore 1977: 63; Moore *et al.* 1987: 146; Baehr 1997: 3; 1999: 147.

This species is only known from the type locality Lake Eyre (Moore *et al.* 1987). In the SAMA collection there is a large series of specimens from Madigan Gulf and Prescott Gulf (both Lake Eyre North). Thus, *P. grossi* seems to have colonised a large part of the shores of this lake.

Pogonus hypharpagioides Sloane
(Fig. 1)

Sloane 1895: 126; Moore 1977: 63; Moore *et al.* 1987: 146; Baehr 1997: 2, 3; 1999: 147.

In addition to its type locality, Lake Callabonna, *P. hypharpagioides* has previously been recorded from Lake Eyre (Moore *et al.* 1987) and Lake Frome (Baehr 1997). Collections made by the authors show this species is widely distributed throughout the salt lake belt from northwestern Victoria to the west coast of South Australia, including some near-coastal localities (see Fig. 1). A variety of techniques have been employed in collecting this species; many specimens were excavated from burrows, others were collected at light, in pitfall traps or while running on the surface at night.

Pogonus variabilis Moore

Moore 1991: 31; Baehr 1997: 2; 1999: 147.

In the collection of SAMA there is a series of specimens caught by N. B. Tindale and P. Aitken in 1963 at Normanton and on Mornington Island, both northwestern Queensland, that apparently escaped the attention of Moore when he described this species in 1991. They are evidence of the wide range of this species along the coasts of tropical Australia. Characteristically, they have been collected at light.

Descriptions Of New Species

Pogonus matthewsi sp. nov.
(Figs 2, 5, 8, 19)

Types

Holotype: male, P. Hudson. 3 Sept. 1996,

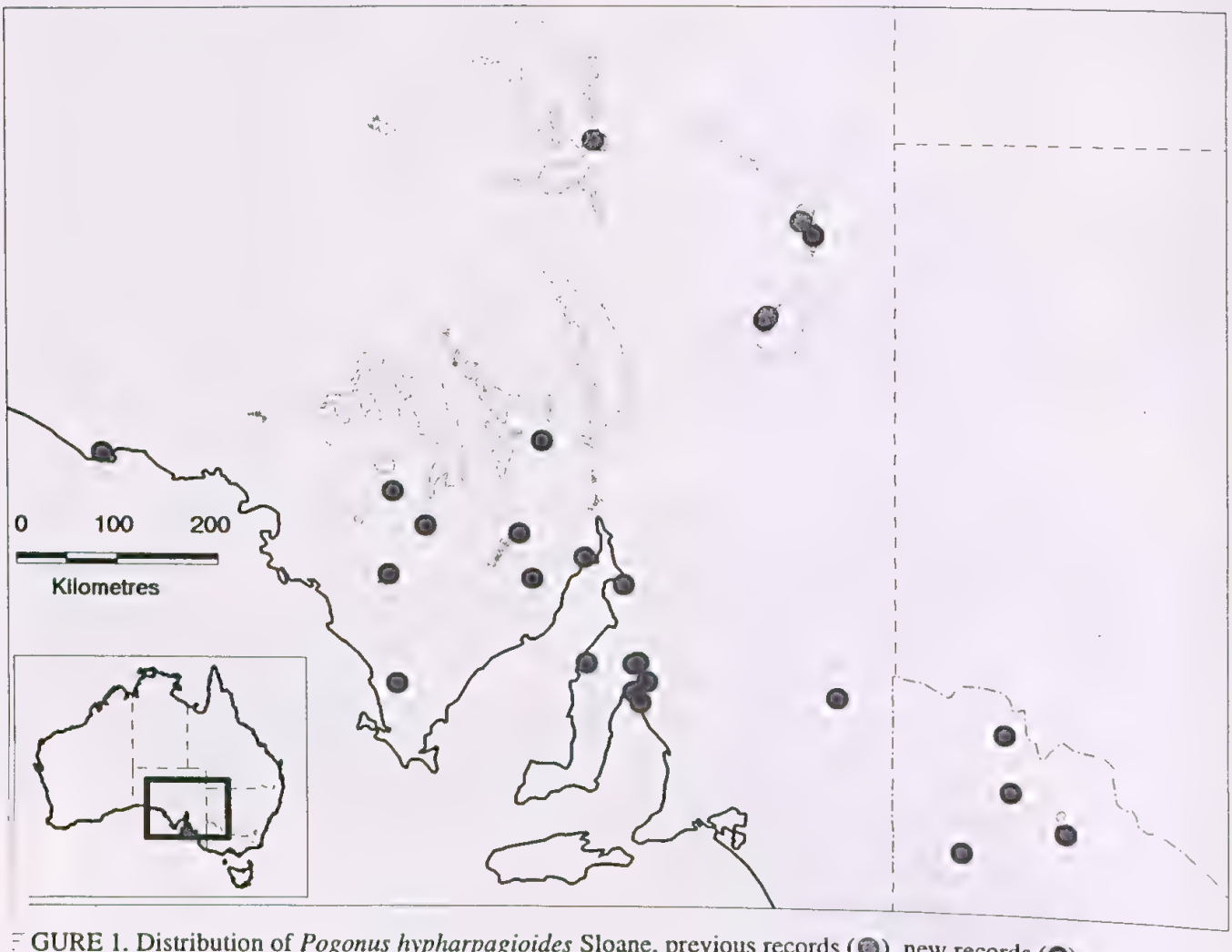


FIGURE 1. Distribution of *Pogonus hypharpagioides* Sloane, previous records (●), new records (●).

Pernatty Lagoon (sth), SA 31.6625°S 137.2375°E (SAMA). Paratypes: 5 females, same data (CBM, SAMA).

Diagnosis

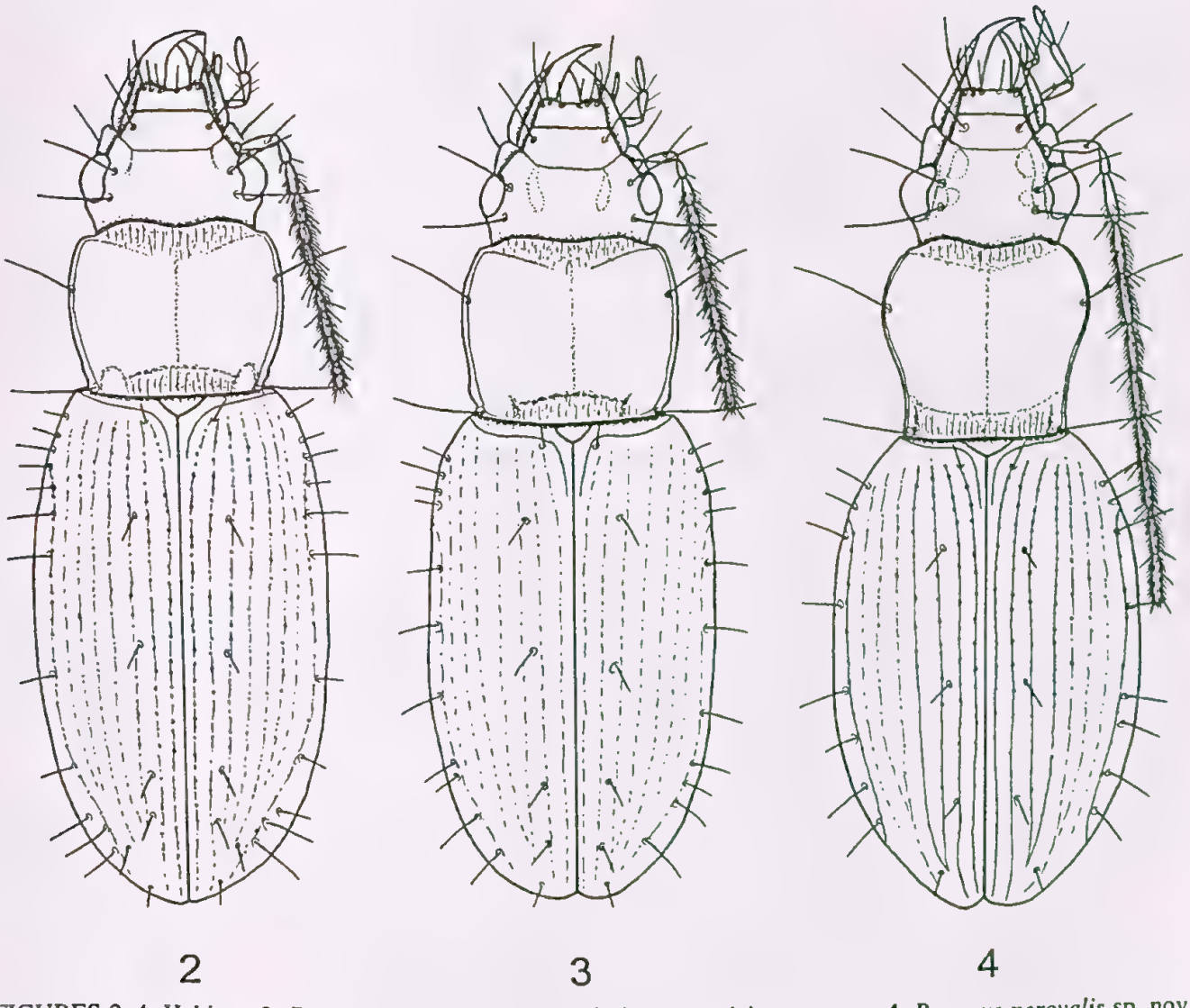
Moderately small, elongate, uniformly reddish 'syrdeniform' species, distinguished from related species mainly by its convex elytra with distinct microreticulation and markedly convex intervals, and its comparatively stout legs with wide metafemur and strongly depressed tibiae. Further distinguishing characters are in Tables 1 and 2.

Description

Measurements: Length: 5.6–6.2 mm; width: 1.9–2.0 mm. Ratios: Width/length of pronotum: 1.15–1.17; width base/apex of pronotum: 0.96–1.02; width of pronotum/width of head: 1.12–1.16; length/width of elytra: 1.86–1.90; width elytra/pronotum:1.26–1.28. Elytral ratios are only based on two specimens since all are weakly sclerotised and most have their elytra opened and somewhat distorted.

Colour: All known specimens freshly hatched, hence mature colouration somewhat uncertain. Upper and lower surfaces including mouth parts, antennae, and legs yellow. Apex of mandibles dark.

Head (Fig. 2): Rather large and wide, fairly convex, slightly narrower than pronotum. Eyes rather small, depressed, laterally not much projecting, posteriorly slightly enclosed. Labrum short and wide, apex gently emarginate. Mandibles rather elongate, apex fairly incurved. Palpi of moderate size, penultimate palpomere of labial palpus fairly slender, slightly bowed. Submentum quadrisetose, tooth of mentum wide, slightly cleft, bidentate. Lacinia with elongate spines. Clypeus and frons in middle convex, frontal furrows fairly short, sinuate, rather shallow, posteriorly ending in an irregularly shaped impression. Impressions with irregular wrinkles. Antennae short, well short of reaching base of pronotum, median antennomeres little longer than wide, sparsely pilose from middle of 3rd antennomere, more densely pilose from 5th antennomere. Surface rather glossy, impunctate,



FIGURES 2–4. Habitus. **2.** *Pogonus matthewsi* sp. nov. **3.** *Pogonus vicinus* sp. nov. **4.** *Pogonus perovalis* sp. nov. Lengths: 5.6 mm; 6.0 mm; 5.5 mm.

microreticulation rather superficial, approximately isodiametric.

Pronotum (Fig. 2): Slightly wider than long, moderately convex, not cordiform, widest at anterior third slightly behind position of anterior lateral seta. Base about as wide as apex. Apex well produced beyond anterior angles, convex, in middle emarginate. Anterior angles very sharply rounded off, almost rectangular. Lateral border evenly convex throughout, with a very short concavity just in front of basal angles. Marginal channel narrow, border slightly upturned. Basal angles rectangular, dentiform, base convex, laterally rather oblique. Both apex and middle of base unmargined. Anterior transverse sulcus fairly distinct, median line very shallow, attaining base though not apex, basal transverse sulcus shallow though distinct. Basal grooves circular, merging into marginal channel. Anterior lateral seta situated in front of anterior third and of widest diameter, posterior marginal seta arising from basal angle. Both apex and base rugosely punctate-striolate. Disk very finely punctate or almost impunctate, at least laterally with more or less distinct, somewhat isodiametric microreticulation, with very faint, irregularly transverse strioles, glossy.

Elytra (Fig. 2): Elongate, narrow, rather parallel, dorsally remarkably convex, widest at middle. Humeri very obtusely angulate. Lateral margin straight over most of its distance, little narrowed towards humeri, contiguous at sutural angle. Marginal channel extremely narrow, margin not explanate. All striae complete, well impressed, coarsely punctate. Eighth stria not bowed away from margin. Basal margin evenly curved into short scutellar stria medially of 1st stria. Intervals rather convex. Third interval with 4, rarely

unilaterally 3 setiferous punctures, the anterior and median ones adjacent to 3rd stria, situated about at basal third and at middle, the third and fourth ones in posterior third attached to 2nd stria. 11–12 widely spaced submarginal punctures in a more or less uninterrupted row attached to 8th stria. Scutellar pore and seta present, at base of 1st stria. Intervals impunctate, with very conspicuous, isodiametric microreticulation. Wings fully developed.

Lower surface: Prosternum not pilose. Metepisternum rather elongate, slightly more than half longer than wide at apex. Terminal sternum in male bisetose, in female quadrisetose.

Legs: Rather short and stout, metafemur comparatively stout, tibiae strongly depressed, with sparse and weak spination. Tibial spurs moderately elongate. Tarsi rather short, 1st tarsomere of metatarsus much shorter than both following tarsomeres. Metatrochanter in both sexes short, wide, a third of length of metafemur, apex obtusely rounded. Tarsomeres 1–3 of male protarsus slightly asymmetrically widened on median side, 1st tarsomere biseriately squamose, 2nd tarsomere with few squamae on median border only.

Male genitalia (Fig. 5): Genital ring rather regularly triangular, little sclerotised, because the holotype is freshly hatched. Aedeagus small, short and compact, laterally depressed, slightly asymmetric, lower surface regularly though gently curved, apex rather short, obtuse at tip, slightly turned to right side. Internal sac with a coiled, circular, sclerotised plate near base, and with a distinctly denticulate, triangular fold near apex. Right paramere narrow, slightly shorter than left, with 3 elongate apical setae. Left paramere large, convexly tapering to apex, with 2 elongate and 1 short apical setae, the short one situated below the longer ones.

Female genitalia (Fig. 8): Stylomere 1 without setae at apex. Stylomere 2 elongate, curved, with 1 or 2 small ventral ensiform setae near base, and 2 (attached) nematiform setae originating from a groove near apex.

Variation: Only some variation of relative length of elytra and width of pronotum noted.

Distribution (Fig. 19)

So far recorded only from Pernatty Lagoon, slightly west of Lake Torrens, South Australia.

Habits

Specimens were collected following excavation of their burrows. They were widely distributed on parts of the lake surface lacking a salt crust.

Etymology

The name is a patronym in honour of Eric Matthews, Curator of Coleoptera at the South Australian Museum who kindly gave access to the rich collections of pogonines.

Relationships

The species belongs to the *grossi*-complex, and it appears to be most closely related to *P. grossi* Moore and *P. vicinus* sp. nov.

Pogonus vicinus sp. nov.
(Figs 3, 6, 19)

Types

Holotype: male, P. Hudson 9 July 1997 SEG Exp. Lake Frome 30.6667°S 139.6028°E (SAMA). Paratypes: 1 male, P. Hudson Jul 1997 pit trap, Lake Frome, SA 30.6667°S 139.6028°E (CBM); 1 male, G. Medlin 18 May, 1997 Lake Frome, SA 30.6667°S 139.6028°E (SAMA).

Diagnosis

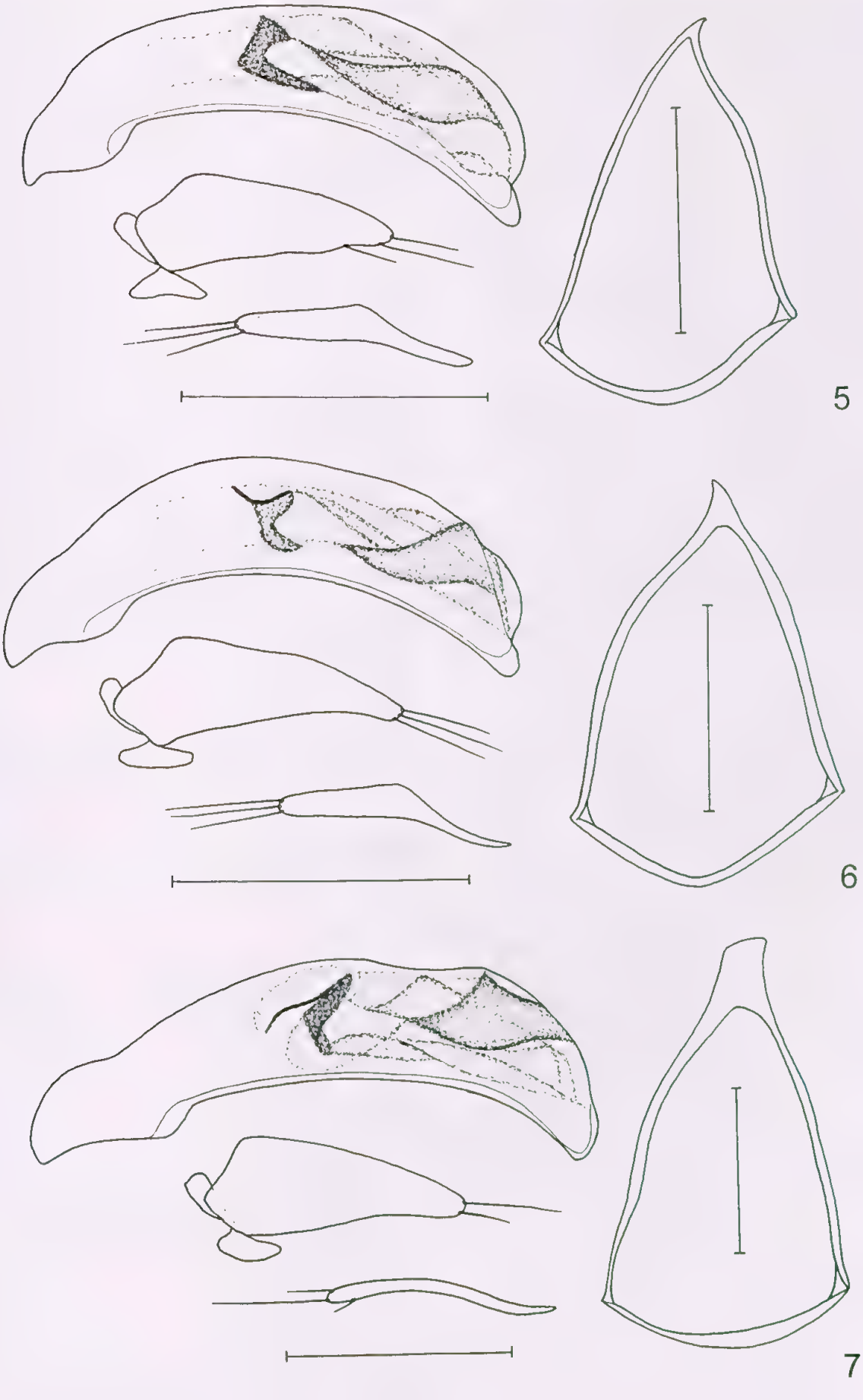
Moderately small, elongate, uniformly reddish 'syrdeniform' species, distinguished from related species mainly by its rather short and wide elytra with shallow, barely punctate striae, and the rather straight though anteriorly abrupt convex lateral margins of pronotum. Distinguishing characters are summarised in Tables 1 and 2.

Description

Measurements: Length: 5.1–6.0 mm; width: 1.85–2.10 mm. Ratios: Width/length of pronotum: 1.13–1.16; width base/apex of pronotum: 0.98–1.01; width of pronotum/width of head: 1.16–1.21; length/width of elytra: 1.72–1.77; width elytra/pronotum:1.30–1.44.

Colour: Upper and lower surfaces including mouth parts, antennae, and legs dark yellow. Apex of mandibles dark.

Head (Fig. 3): Rather large and wide, fairly convex, slightly narrower than pronotum. Eyes rather small, fairly depressed, laterally not much projecting, posteriorly slightly enclosed. Labrum short and wide, apex gently emarginate. Mandibles moderate, apex fairly incurved. Palpi of moderate size, penultimate palpomere of labial palpus fairly slender, slightly bowed. Submentum quadrisetose, tooth of mentum wide, slightly cleft, bidentate. Lacinia with elongate spines. Clypeus and frons convex in middle, frontal furrows fairly



FIGURES 5–7. Male genitalia: Aedeagus, left side, parameres, genital ring. **5.** *Pogonus matthewsi* sp. nov. **6.** *Pogonus vicinus* sp. nov. **7.** *Pogonus perovalis* sp. nov. Scales: 0.5 mm.

short, sinuate, fairly shallow, posteriorly ending in an irregular impression. Antennae rather short, not attaining base of pronotum, median antennomeres about a third longer than wide, sparsely pilose from middle of 3rd antennomere, more densely pilose from 5th antennomere. Surface glossy, impunctate, without microreticulation.

Pronotum (Fig. 3): Slightly wider than long, rather depressed, not cordiform, widest at anterior third slightly behind position of anterior lateral seta. Base about as wide as apex. Apex slightly produced beyond anterior angles, convex, emarginate in middle. Anterior angles very sharply rounded off, almost rectangular. Lateral border anteriorly convex or even almost oblique, then oblique and straight, just in front of basal angles incurved and forming a very small concavity. Marginal channel narrow, posteriorly slightly widened, border slightly upturned. Basal angles rectangular, very faintly dentiform, base convex, laterally rather oblique. Both apex and middle of base unmargined. Anterior transverse sulcus fairly distinct, median line very shallow, attaining base though not apex, basal transverse sulcus moderately shallow, distinct. Basal grooves circular, merging into marginal channel. Anterior lateral seta situated in front of anterior third and point of greatest width, posterior marginal seta arising from basal angle. Apex and base rugosely punctate-striolate. Disk impunctate, without microreticulation, with very faint, irregularly transverse strioles, glossy.

Elytra (Fig. 3): Comparatively short and wide for group, moderately narrow, not parallel, dorsally rather depressed, widest at middle. Humeri very obtusely angulate or almost rounded. Lateral margin gently convex over most of its distance, slightly narrowed towards humeri, contiguous at sutural angle. Marginal channel extremely narrow, margin not explanate. All striae complete, not much impressed, almost impunctate. Eighth stria not bowed away from margin. Basal margin evenly curved into short scutellar stria medially of 1st stria. Intervals depressed. Third interval with 4, rarely unilaterally 3 or 5 setiferous punctures, the anterior and median ones adjacent to 3rd stria, situated about at basal third and at middle, the third and fourth ones in posterior third attached to 2nd stria. 10–11 widely spaced submarginal punctures in a more or less interrupted row attached to 8th stria. Scutellar pore and seta present, at base of 1st stria. Intervals impunctate, with fairly superficial, isodiametric microreticulation. Wings fully developed.

Lower surface: Prosternum not pilose. Metepisternum rather elongate, about a half longer than wide at apex. Terminal sternum in males bisetose, unknown in females.

Legs: Rather short and stout, metafemur moderately stout, tibiae fairly well depressed, with sparse and weak spination. Tibial spurs moderately elongate. Tarsi rather short, 1st tarsomere of metatarsus much shorter than both following tarsomeres. Metatrochanter in males short, wide, a third of length of metafemur, apex obtusely rounded. Tarsomeres 1–3 of male protarsus slightly asymmetrically widened on median side, 1st tarsomere biseriately squamose, 2nd tarsomere with few squamae on median border only.

Male genitalia (Fig. 6): Genital ring rather regularly triangular. Aedeagus small, short and compact, laterally depressed, slightly asymmetric, lower surface regularly though gently curved, apex rather short, obtuse at tip, slightly turned to right side. Internal sac with a coiled, circular, sclerotised plate near base, and with a distinctly denticulate, triangular fold near apex. Right paramere narrow, slightly shorter than left, with 3 elongate apical setae. Left paramere large, comparatively elongate, tapering to apex, with 3 elongate apical setae.

Female genitalia: Unknown.

Variation: Only some variation of relative width of pronotum noted.

Distribution (Fig. 19)

So far recorded only from Lake Frome, southeast of Lake Eyre, South Australia.

Habits

Excavated from burrows in the lake surface and collected by pitfall trapping.

Etymology

The name refers to the strong similarity of this species to the related *P. grossi* Moore and *P. matthewsi* sp. nov.

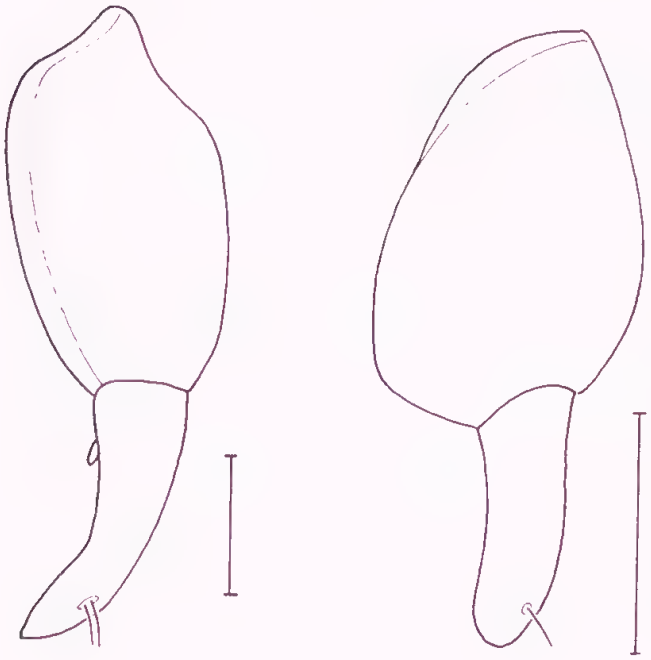
Relationships

The species belongs to the *grossi*-complex, where it apparently takes a position near *P. grossi* Moore and *P. matthewsi* sp. nov.

Pogonus perovalis sp. nov.
(Figs 4, 7, 9, 10, 19)

Types

Holotype: male, P. Hudson (SEG Exp 95) Jul



FIGURES 8–9. Female stylomeres 1 and 2. **8.** *Pogonus matthewsi* sp. nov. **9.** *Pogonus perovalis* sp. nov. Scales: 0.1 mm.

1995 pit traps Lake Gairdner, SA 32.3014°S 135.8867°E (SAMA). Paratypes: 2 males, 1 female, same data (CBM, SAMA); 1 female, P. Hudson 3 Sep 1996 Island Lagoon, SA 31.4139°S 136.9292°E (SAMA); 1 female, Remko Leijs 30 Jun 1996 Lake Hart, SA 31.2278°S 136.3792°E (SAMA).

Diagnosis

Rather small, convex, apparently depigmented species, at once distinguished by the oval-shaped, convex elytra, convex, rather cordiform pronotum, and elongate antennae.

Description

Measurements: Length: 4.35–5.70 mm; width: 1.60–2.10 mm. Ratios: Width/length of pronotum: 1.03–1.12; width base/apex of pronotum: 0.88–0.96; width of pronotum/width of head: 1.10–1.18; length/width of elytra: 1.49–1.53; width elytra/pronotum:1.49–1.56. Elytral ratios are only based on a few specimens since all are weakly sclerotised and most have their elytra opened and somewhat distorted.

Colour: Apparently depigmented, though all known specimens freshly hatched, hence colouration somewhat uncertain. All specimens very light yellowish. Only apex of mandibles dark.

Head (Fig. 4): Fairly large, rather depressed, slightly narrower than pronotum. Eyes large, rather convex, laterally well projecting, posteriorly not enclosed. Labrum short and wide, apex straight. Mandibles very elongate, somewhat decussate, apex incurved. Palpi elongate, apical palpomeres somewhat incised, slightly subulate. Penultimate palpomere of labial palpus slender, slightly bowed. Submentum bisetose, tooth of mentum wide, slightly cleft, bidentate. Lacinia with elongate spines. Clypeus and frons convex in middle, frontal furrows fairly elongate, rather sinuate, fairly shallow, at posterior end forming an irregular impression. Irregular wrinkles within and between impressions. Antennae very elongate, surpassing base of pronotum by almost 4 antennomeres, median antennomeres > 3 x as long as wide, pilose from middle of 3rd antennomere. Surface glossy, impunctate, without any microreticulation.

Pronotum (Fig. 4): Slightly wider than long, convex, rather cordiform, widest at anterior third approximately at position of anterior lateral seta. Base slightly narrower than apex. Apex produced beyond anterior angles, feebly convex. Anterior angles sharply rounded off. Lateral border evenly convex in anterior two thirds, then gently concave to basal angles. Marginal channel extremely narrow, border slightly upturned, forming a sharp edge. Basal angles rectangular, base slightly convex. Apex and base unmargined. Anterior transverse sulcus barely indicated, median line very shallow, attaining base though not apex, basal transverse sulcus very shallow. Basal grooves shallow, circular, merging into marginal channel. Anterior lateral seta situated at anterior third, at point of greatest width, posterior marginal seta arising from basal angle. Both apex and base rugosely punctate-striolate. Disk impunctate and without microreticulation, highly glossy, with some very faint, transverse strioles.

Elytra (Fig. 4): Short, markedly oval-shaped, convex, widest at or slightly behind middle. Humeri angulate, more or less rectangular. Lateral margin evenly convex throughout. Marginal channel narrow, margin not explanate. All striae complete, well impressed, punctate. Eighth stria originating at basal fifth, slightly bowed away from margin. Basal margin evenly curved into short scutellar stria medially of 1st stria. Intervals depressed to very feebly convex. Third interval with 3 setiferous punctures, the anterior and median ones adjacent to 3rd stria, situated at about basal third and at middle, the third puncture in posterior third attached to 2nd stria. Nine, rarely 10

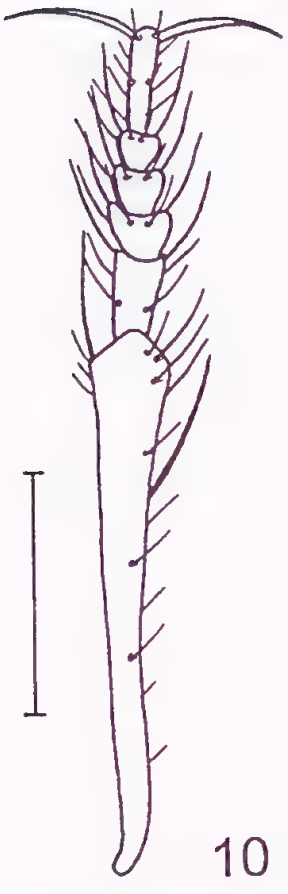


FIGURE 10. *Pogonus perovalis* sp. nov. Right protibia and tarsus, dorsolateral view.

widely spaced submarginal punctures in an uninterrupted row attached to 8th stria. Scutellar pore and seta present, at base of 1st stria. Intervals impunctate, though with very distinct, absolutely isodiametric microreticulation. Wings absent.

Lower surface: Prosternum not pilose. Metepisternum very short, shorter than wide at apex. Terminal sternum in male bisetose, in female quadrisetose.

Legs (Fig. 10)*:* Remarkably slender and elongate, especially femora and tibiae. Tibiae not at all depressed, almost circular, with sparse and weak spination. All tibial spurs elongate. Tarsi rather short, 1st tarsomere of metatarsus shorter than both following tarsomeres. Metatrochanter in both sexes short, wide, a quarter of length of metafemur, apex obtusely rounded. Tarsomeres 1–3 of male protarsus slightly asymmetrically widened on median side, 1st tarsomere biseriately squamose, 2nd tarsomere with few squamae on median border only.

Male genitalia (Fig. 7): Genital ring rather regularly triangular. Aedeagus comparatively large, fairly elongate, laterally depressed, slightly asymmetric, lower surface almost straight, in apical third markedly concave. Apex laterally very depressed, scuriform, slightly turned to right side. Internal sac with a coiled, circular, sclerotised plate near base, and with a distinctly denticulate, triangular fold near apex. Right paramere very slender and elongate, slightly shorter than left, with one very elongate and two shorter apical setae, the elongate situated in middle. Left paramere large, comparatively elongate, tapering to apex, with 1 very elongate apical seta and a short, delicate seta below.

Female genitalia (Fig. 9): Stylomere 1 apparently without setae at apex. Stylomere 2 moderately elongate, barely curved, with wide, obtuse apex, without ventral ensiform setae, with 2 (attached) nematiform setae originating from a groove very close to apex.

Variation: Apart from some differences in size, little variation noted.

Distribution (Fig. 19)

Recorded from Lake Gairdner, Island Lagoon, and Lake Hart, all South Australia.

Habits

Collected in pitfall traps on the lake surface.

Etymology

The name refers to the markedly ovate elytra of this flightless species.

Relationships

Phylogenetically rather isolated species, but may be remotely related to the *P. grossi* species complex.

Syrdenoidius gen. nov.

Type species: *Syrdenoidius spinipes* sp. nov., by monotypy.

Diagnosis

Genus of subfamily Pogoninae. In many respects highly similar to the Palaearctic genus *Syrdenus* Chaudoir, *e.g.* narrow, elongate, depressed body shape; absence of microreticulation on elytra; markedly angulate, even dentate humeri; wide 9th elytral interval; short, quadrate antennomeres. However, there are some striking pecularities in *Syrdenoidius*: asetose prosternum; presence of several rows of remarkably elongate spines on all tibiae (particularly conspicuous on protibia), that occupy almost the whole length of the tibiae; prolongation of 8th elytral stria to humerus; absence of scutellar

striole and pore; absence of hind wings, and quadrate metepisternum; very elongate, forceps-like mandibles; very unusual female genitalia with extremely short, straight stylomere 2.

Etymology

The name refers to the strong similarity in external morphology to the genus *Syrdenus*.

Relationships

Whereas the similarity of some characters in *Syrdenus* and *Syrdenoidius* is probably coincidental, several could point to a closer relationship of both genera. This is especially true for the wide 9th elytral interval that bears on its median margin the marginal pores and setae that are, therefore, far removed from the lateral margin of the elytra. On the other hand, elongate, depressed body shape is an adaptation common within several pogonine genera, not only in *Syrdenus*, but also in *Pogonus* proper and in *Pogonistes*. We think that the genus *Syrdenoidius* is a highly isolated one though it possibly has closest affinities with *Syrdenus*. Whilst *Syrdenus* is so far decidedly a Palaearctic genus there is, however, an as yet undescribed species known from West Bengal, northeastern India, that demonstrates that the genus has a wider distribution than commonly believed. If the genus *Syrdenus* is a relict of the former Tethys fauna, then a relationship with the fauna of western and northwestern Australia might well be possible since it has been argued that this area formerly had contact with the Tethys or was even part of its southern shore (Eric Matthews, 1998, pers. com.). This question may be settled in the future by more intensive sampling along the coast and on the inland lakes of Western Australia.

Syrdenoidius spinipes sp. nov.
(Figs 11–19)

Types

Holotype: male, S. AUST. L. Gairdner 32°07'S 135°53'E 14 July 95 P. Hudson (SAMA). Paratypes: 6 males, 13 females, same data (ANIC, CBM, SAMA); 1 female, P. Hudson 14 July 1995 SEG Exp. 95 Lake Gairdner 32°07'47"S 135°53'19"E (SAMA).

Diagnosis

Medium-sized, very elongate, narrow, depressed, depigmented species with large, convex head, large though depressed eyes, very elongate mandibles, almost regularly trapezoidal pronotum that is widest at apex, non-microreticulate surface, and remarkably spinose tibiae.

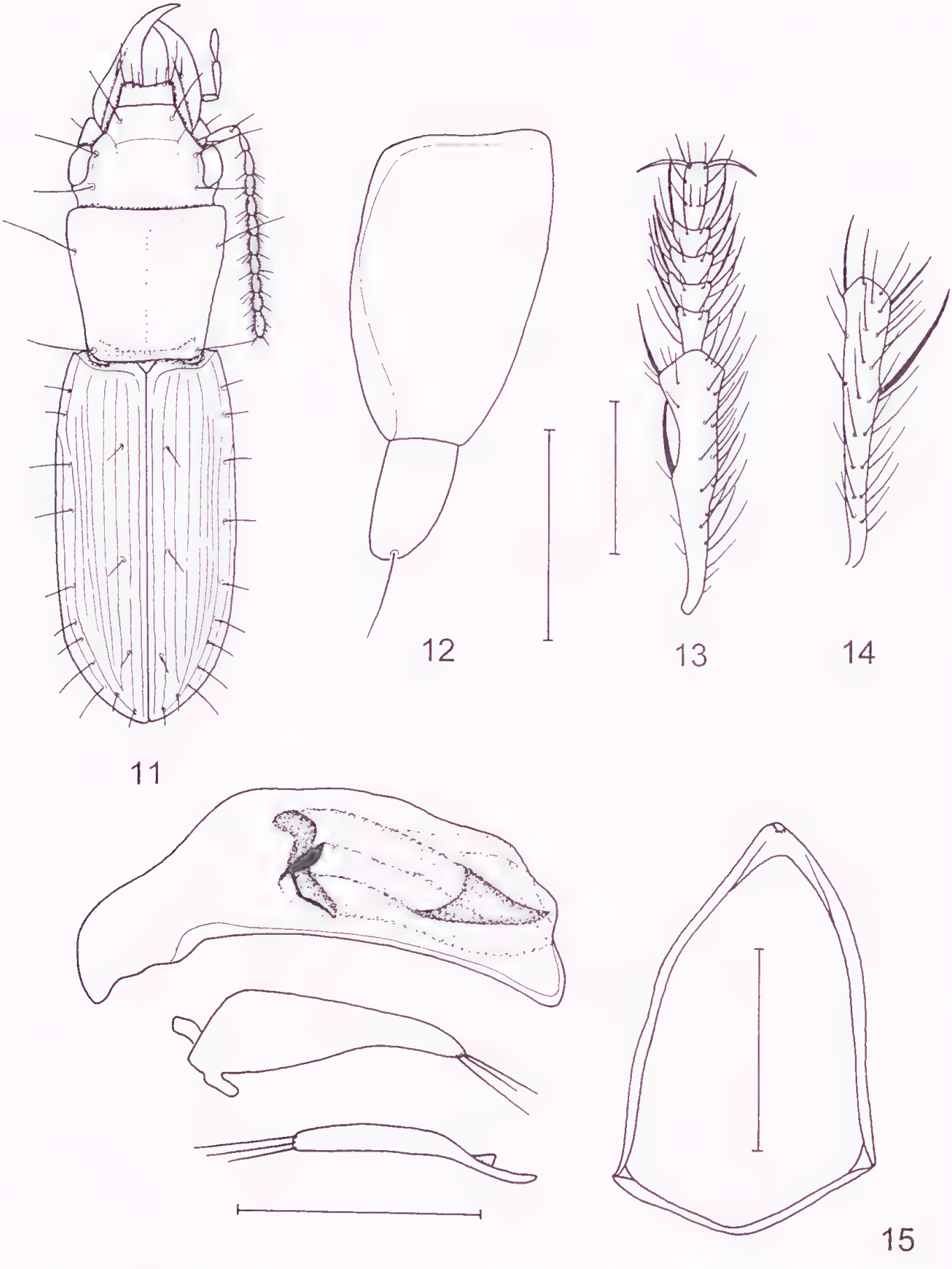
Description

Measurements: Length: 5.4–6.3 mm; width: 1.50–1.65 mm. Ratios: Width/length of pronotum: 1.03–1.08; width base/apex of pronotum: 0.73–0.77; width of pronotum/width of head: 1.04–1.07; length/width of elytra: 2.06–2.12; width elytra/pronotum:1.12–1.16.

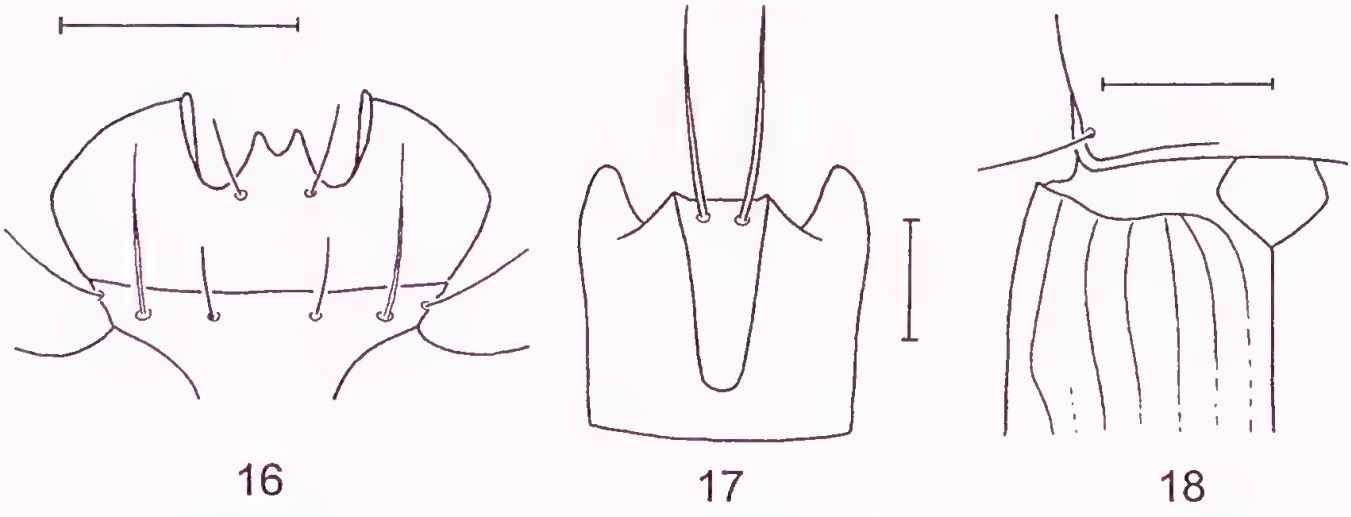
Colour: Upper and lower surface, including mouth parts, antennae, and legs light reddish, elytra very slightly lighter. Apex of mandibles darker.

Head (Figs 11, 16–18): Large, convex, slightly narrower than pronotum. Eyes large though remarkably depressed, laterally barely projecting, posteriorly not enclosed. Lower rim of eye forming a sharp edge that slightly surpasses the eye laterally. Labrum short and wide, apex fairly emarginate. Mandibles very elongate, somewhat decussate, apex strongly incurved. Palpi elongate, apical palpomeres somewhat incised, slightly subulate. Penultimate palpomere of labial palpus very slender, slightly bowed. Submentum sexsetose, tooth of mentum wide, deeply cleft, markedly bidentate (Fig. 16). Lacinia with very elongate spines. Ligula bisetose, paraglossae slightly surpassing glossa (Fig. 17). Clypeus and frons convex in middle, frontal furrows elongate, slightly sinuate, beginning on clypeus. Frons behind frontal furrows with a wide, circular, shallow impression on either side, irregular wrinkles between impressions. Antennae short, wide, not attaining base of pronotum, median antennomeres almost as wide as long, sparsely pilose from middle of 3rd antennomere, more densely pilose from 5th antennomere. Surface glossy, impunctate, without any microreticulation.

Pronotum (Figs 11, 18): Barely wider than long, remarkably trapezoidal, widest at apex. Surface moderately convex. Apex little produced beyond anterior angles, in middle with very shallow, triangular excision. Anterior angles broadly rounded. Lateral margin almost straight, oblique, slightly rounded only near apex, faintly incurved towards base. Border somewhat irregular, bearing several slight notches. Basal angles obtusely rounded, base almost straight. Marginal channel extremely narrow, margin forming a fairly sharp ridge. Apex unmargined, base coarsely margined, margin narrowly surrounding basal angles and meeting lower margin of epipleura, this margin



FIGURES 11–15. *Syrdenoidius spinipes* gen. nov., sp. nov. **11.** Habitus. Length 5.6mm. **12.** Female stylomeres 1 and 2. Scale 0.1mm. **13.** Right protibia and tarsus, dorsal view. **14.** right protibia, dorsolateral view. Scale: 0.5 mm. **15.** Male genitalia: Aedeagus, left side, parameres, genital ring. Scale 0.5mm.



FIGURES 16–18. *Syrdenoidius spinipes* gen. nov. sp. nov. **16**. Mentum and submentum, ventral view. Scale: 0.5 mm **17**. Ligula, ventral view. Scale: 0.1 mm. **18**. Base of left elytron. Scale 0.5 mm.

sometimes even visible from above (Fig. 18). Anterior transverse sulcus barely indicated, median line very shallow, deepened near base, attaining apex and base. Basal transverse sulcus shallow though distinct. Base coarsely striolate, basal grooves rather shallow, irregular. Anterior marginal seta inserted at anterior fourth, posterior seta situated just in front of basal angle, anterior and posterior setae slightly removed from margin. Disk impunctate and without any microreticulation, highly glossy, though laterally with some transverse striolations.

Elytra (Figs 11, 18): Very narrow and elongate, parallel-sided, markedly depressed. Humeri very sharply projecting, markedly angulate. Lateral margin gently oblique or slightly convex in basal fourth, then parallel, only in apical fourth convex again. Marginal channel narrow throughout. Apical angles broadly rounded, apex in middle slightly incised. No internal plica visible from outside. Striae complete, deep, not punctate, but somewhat irregular, sometimes interrupted or with anastomoses. Eighth stria bowed away from margin in anterior fourth, laterally leaving a wide space, though anteriorly attaining humerus. Basal margin evenly curved into 1st stria, no scutellar stria present. Scutellar pore and seta absent. Intervals convex, though their surface rather uneven. Third interval with 3 setiferous punctures adjoining 3rd stria, the first situated in anterior third, the second in middle, the third in apical third, but their position rather variable. Submarginal punctures far removed from margin, adjoining lateral margin of 8th stria, consisting of 4 punctures in anterior group and 6 punctures in posterior group, with a wide space between them. Also with 1 puncture at end of 5th interval and 2nd interval. Surface impunctate, without microreticulation, highly glossy. Wings almost completely reduced.

Lower surface: Prosternum not pilose. Metepisternum short, barely longer than wide at apex. Terminal sternum in male bisetose, in female quadrisetose.

Legs (Figs 13, 14): Moderately elongate. Protibia and mesotibia with 4 rows of remarkably stout and elongate spines all along dorsal, lateral, and latero-ventral surfaces. Metatibia less spinose. Apical tibial spurs of protibia and mesotibia remarkably elongate, much longer than 1st tarsomere. Tarsi rather short, 1st tarsomere of metatarsus shorter than both following tarsomeres. Tarsi remarkably hirsute. Tarsomeres 1–3 of male protarsus slightly asymmetrically widened on median side, 1st and 2nd tarsomeres with few squamae on median border. Metatrochanter in both sexes less than half as long as metafemur, obtuse at apex.

Male genitalia (Fig. 15): Genital ring wide, in basal half almost quadrangular, apically regularly triangular, rather symmetric. Aedeagus short and very compact, laterally depressed, slightly asymmetric, lower surface barely curved, apex very short, obtuse, barely turned laterally. Internal sac with a complexly coiled, in parts heavily sclerotised plate near base, and with a distinctly denticulate, triangular fold near apex. Right paramere moderately narrow, about a third shorter than left, with 3 elongate apical setae. Left paramere elongate, rather slender, abruptly narrowed to the downcurved apex, with 3 elongate apical setae.

Female genitalia (Fig. 12): Stylomere 1 apparently without setae at apex. Stylomere 2 very short, straight, almost quadrate, with wide, convex apex, without ensiform setae, though with an elongate nematiform seta arising from apex.

Variation: Very little variation noted.

Distribution (Fig. 19)

Only recorded from Lake Gairdner, South Australia.

Habits

Excavated from burrows in the lake surface.

Etymology

The name refers to the remarkably spinose tibiae of this species.

KEY TO THE GENERA OF AUSTRALIAN POGONINAE

1. — Elytra without microreticulation; humerus sharply angulate (Figs 11, 18); protibia with several rows of elongate spines on dorsal and lateral surfaces that occupy almost the whole length (Figs 13, 14); pronotum remarkably trapezoidal, widest at anterior angles (Fig. 4). Lake Gairdner, SA..... *Syrdenoidius* gen. nov. (only *S. spinipes* sp. nov.)

2. — Elytra with distinct microreticulation; humerus not so angulate (Figs 2–4); protibia with a short row of moderate spines on lateral surface only (Fig. 10); pronotum differently shaped, widest far behind anterior angles (Figs 2–4). Widely distributed in Australia .... *Pogonus* Dejean

KEY TO THE AUSTRALIAN SPECIES OF THE GENUS *POGONUS* DEJEAN

1. — Body completely metallic green or black..... 2
   — Body entirely or in parts testaceous 5
2. — Colour shining black; punctures of elytra very coarse, microreticulation inconspicuous. Northeastern Queensland, coastal and inland ..... *nigrescens* Baehr
   — Colour greenish metallic; punctures of elytra finer, microreticulation conspicuous. Southern half of Australia 3
3. — Sixth and 7th striae almost similar to inner 5 striae; flightless; elytral margins ovate. Lake Yindarlgooda, Western Australia . .....*fennelli* Hudson
   — Sixth and 7th striae less marked than 5

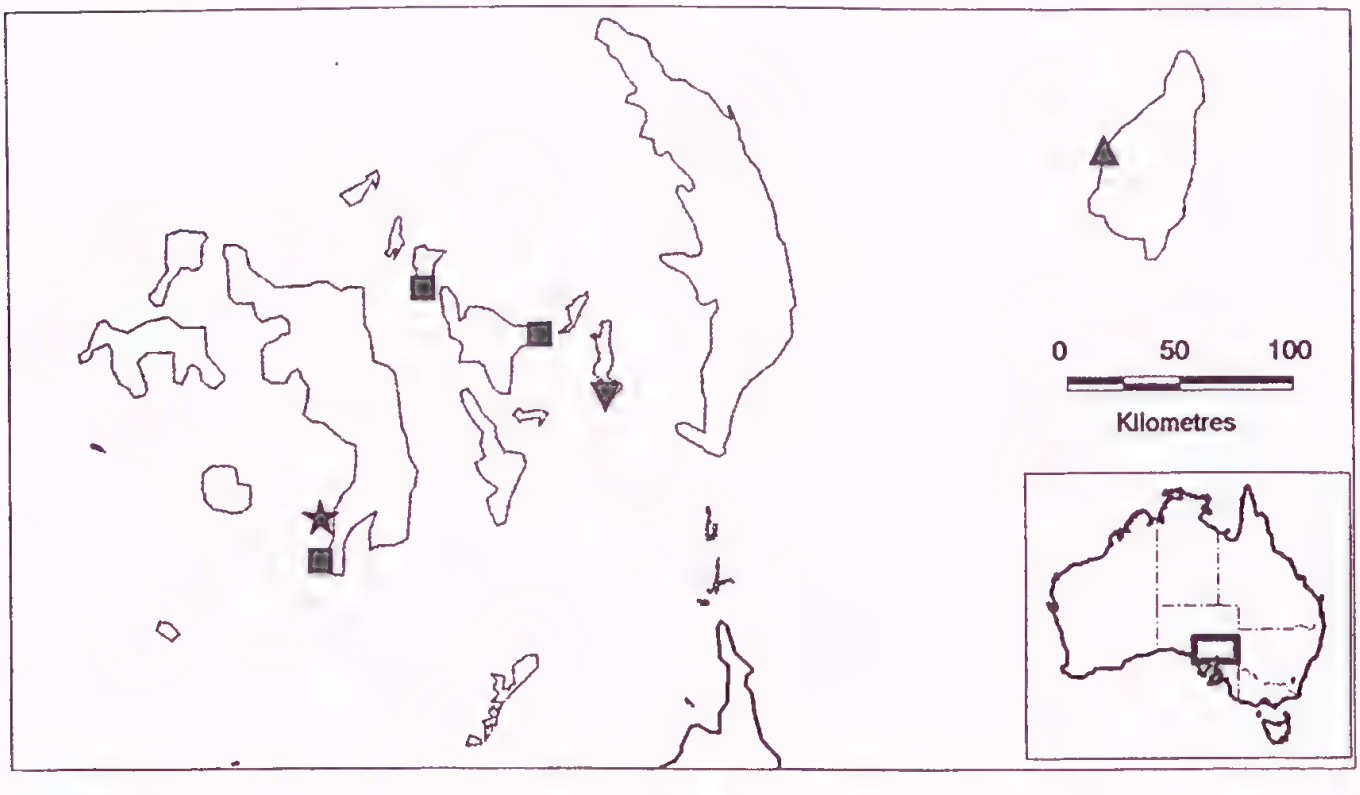


FIGURE 19. Distribution of *Pogonus matthewsi* sp. nov. (▼), *P. vicinus* sp. nov. (▲), *P. perovalis* sp. nov. (■), *Syrdenoidius spinipes* gen. nov., sp. nov. (★).

inner striae; fully winged; elytral margins more parallel sided 4

4. — Smaller (body length 6.3–6.8 mm), body narrower, more convex; pronotum markedly sinuate in front of the acute basal angles, these being 90° or less; submarginal basal ridge of pronotum scarcely indicated. Southern Australia from Western Australia to Victoria along coast ..... *australis* Chaudoir

— Larger (body length 7.5–8.5 mm), body wider, less convex; pronotum less sinuate, basal angles more obtuse, these being c. 100°; submarginal basal ridge of pronotum conspicuous. Coastal and inland from southern half of Western Australia to southeastern Queensland .... *cardiotrachelus* Chaudoir

5. — Bicoloured, head and pronotum distinctly darker than elytra 6

— Completely testaceous or light reddish, head and pronotum not perceptibly darker than elytra (variable species under both couplets) 7

6. — Large, convex species (body length 9–11 mm); pronotum not lobate, distinctly sinuate in front of basal angles. Northern Australia from northwestern Queensland to the Kimberleys, coastal and along tidal rivers ..... *variabilis* Moore

— Small, depressed species (body length c. 6.5 mm); pronotum lobate, barely sinuate in front of basal angles. Inland saline habitats in Western Australia and South Australia ..... *zietzi* Sloane

7. — Large species (body length >9 mm); either pronotum distinctly sinuate in front of basal angles and base about as wide as apex, or pronotum rather quadrate with characteristically bisinuate base, and elytra wide, oval-shaped, and depressed with wide, explanate lateral margin. Northern Australia from northwestern Queensland to Exmouth Gulf, coastal and along tidal rivers 8

— Smaller species (body length <8.5 mm); pronotum distinctly sinuate or not in front of basal angles; but when distinctly sinuate, then base markedly narrower than apex; when not sinuate, then elytra not wide, oval-shaped, and depressed; and with narrower, not explanate lateral margin. Inland in southern half of Australia 9

8. — Pronotum distinctly sinuate in front of basal angles, lateral margin not explanate at base; eyes convex, laterally markedly protruding; elytra less wide and depressed, lateral margin not explanate, striation deeper and more complete, striae distinctly punctate. Northern Australia from northwestern Queensland to the Kimberleys ..... *variabilis* Moore

— Pronotum rather quadrate, lateral margin conspicuously explanate at base; eyes depressed, laterally little protruded; elytra wide and depressed, lateral margin explanate, striation shallow and laterally incomplete, striae more finely punctate. Coast of northwestern Australia south of Great Sandy Desert ..... *sumlini* Baehr

9. — Pronotum distinctly sinuate in front of basal angles and base markedly narrower than apex; left paramere with 2 apical setae, right paramere with a single apical seta. South Australia, Lake Eyre Basin .. .. *gilesi* Moore

— Pronotum either not distinctly sinuate in front of basal angles or base about as wide as apex; left paramere with 3, right paramere with 2 or 3 apical setae 10

10. — Large, convex species (body length 7.2–8.4 mm); head large, pronotum laterally markedly convex. South Australia, northwestern Victoria .... *hypharpagioides* Sloane

— Smaller, more depressed species (body length <6.5 mm); head smaller, pronotum laterally less convex 11

11. — Pronotum rather quadrate, lateral margin evenly curved from apex to base, widest in middle; elytral striae shallow, only 3 inner striae distinct. Interior of Western Australia ..... *diplochaetoides* Baehr

— Pronotum more narrowed to base than to apex, widest in anterior third, lateral margin not so evenly curved; elytral striae deeper, at least 5 inner striae distinct. South Australia 12

12. — Elytra laterally and dorsally convex, oviform; pronotum narrow, convex, with elongate sinuation in front of basal angles (Fig. 4); antenna elongate, median antennomeres >3 x as long as wide. Lake Gairdner, Island Lagoon, Lake Hart ....*perovalis* sp. nov.

— Elytra elongate, parallel, dorsally

depressed; pronotum wide, depressed, with at most a short sinuation in front of basal angles (Figs 2, 3); antenna short, median antennomeres <1.5 x as long as wide 13

13. — Smaller species (body length 4.1–4.9 mm); lateral margin of pronotum straight or slightly concave in front of base, basal angle almost 90°, distinctly projecting. Lake Gairdner, Island Lagoon, Lake Hart ..... *saskiae* Baehr

— Larger species (body length 5.2–6.4 mm); lateral margin of pronotum convex to base, basal angle obtuse, or dentiform 14

14. — Elytra rather convex, intervals remarkably convex, microreticulation conspicuous. Pernatty Lagoon ..... *matthewsi* sp. nov.

— Elytra rather depressed, intervals but slightly convex, microreticulation distinct though not conspicuous 15

15. — Lateral margin of pronotum evenly convex, basal angle not dentiform; elytra longer, striae rather deep, distinctly punctate. Lake Eyre ..... *grossi* Moore

— Lateral margin of pronotum rather straight, in anterior third suddenly convex, basal angle dentiform; elytra shorter, striae rather shallow, barely punctate. Lake Frome ... . *vicinus* sp. nov.

Remarks

The collections included within this paper have been made from lakes ranging up in size from approximately 0.3 km² ('Artaming Lake', south of Lake Acraman) to large systems such as Lake Torrens, Lake Frome, Lake Gairdner, and Lake Tyrell. Usually the collections were made when the lakes were devoid of surface water. The beetles were usually collected during the day by excavating their burrows, the location of which was indicated by a small mound of mud on the lake surface. The beetles occupy a large part of the dry lake surface that is free of salt crust. Some collections have also been made using pitfall traps, even on surfaces covered with a thin salt crust and some specimens were detected while running on the surface at night.

From excavated specimens and pit-trapping at least two species are known to occur on Lake Gairdner, *Syrdenoidius spinipes* and *P. perovalis*. According to Moore (1977), at the shore of Lake Eyre three species have been also found together at light, namely *P. hypharpagioides*, *P. gilesi*, and *P. grossi*. However, as on Lake Gairdner, the three species represent rather different life style types, namely a large, bulky one (*P. hypharpagioides*), a medium sized one (*P. gilesi*, comparable to *P. perovalis*), and an elongate, depressed one (*P. grossi*, comparable to *Syrdenoidius spinipes*). Hence, the species obviously occupy a special niche, at least with respect to food preferences which is demonstrated by their different head sizes and mandible lengths and shapes.

If this and other recent papers on the Australian pogonine fauna are any indication then it is most likely that there are numerous other taxa awaiting collection and description. With the existence of flightless taxa there is an increased likelihood that some species will be highly endemic. Clearly a systematic survey of the salt lake fauna of southern Australia is warranted, in the first instance to establish the extent of the Australian fauna and secondly for conservation purposes since many salt lakes, especially those in Western Australia, are sites of intense mining activity.

The 'island-like' nature of the Australian salt lake habitats and the range in their size and degree of geographic isolation make studies of their fauna particularly interesting from an evolutionary and genetic perspective (*e.g.* see Hudson and Adams 1996). Desender and Serrano (1999) have highlighted the value of using electrophoresis techniques in the study of variation in Atlantic and Mediterranean European populations of *Pogonus chalceus* and similar such studies could provide valuable insight to the Australian pogonines.

Wing atrophy and flightlessness in beetles has been documented by numerous authors (Kavanaugh 1985, Roff 1990, and references therein). In pogonines outside Australia, full wing atrophy is only known in the Californian *Thalassotrechus barbarae* (Horn), an intertidal species which is outstanding also in other morphological characters. Principally, all other known pogonines possess fully developed wings and are capable of flight. However, reduction in wing size and lack of functional flight musculature is known in some *Pogonus chalceus* populations (Desender 1989, pers. com. 1999), though the Mediterranean populations of that species are capable of flight (Ravizza 1972). Hence, from the viewpoint of wing development the Australian pogonine fauna seems to be highly unusual, because full reduction of wings is known in three rather different Australian groups, the

genus *Syrdenoidius* and the fully pigmented and depigmented species groups of the genus *Pogonus*.

It should be stressed, however, that in Australia at least, there is a clear difference between species inhabiting saline coastal habitats and those that exclusively live on inland salt lakes. Unlike in the Mediterranean, for example, the Australian sea shores are inhabited only by quite large, convex species of normal 'pogoniform' habitus (*P. australis*, *P. cardiotrachelus*, *P. nigrescens*, *P. sumlini*, *P. variabilis*), most of which are pigmented, whereas elongate, depressed, depigmented 'syrdeniform' species are completely absent from these environments. These latter species occur in saline inland environments together with pigmented species (*P. cardiotrachelus*, *P. fennelli*), and convex, medium-sized or large, either depigmented or partly depigmented species (*P. gilesi*, *P. hypharpagioides*, *P. zietzi*). Flightless species have been found only in inland environments (*P. fennelli*, *P. perovalis*, *Syrdenoidius spinipes*).

If we argue that the pigmented 'pogoniform' species, from the viewpoint of phylogeny, are most plesiotypic, and the depigmented 'syrdeniform' species most apotypic, then the interior saline environment in Australia has a very diverse, highly evolved pogonine fauna, which is evidence of a long term history of the fauna. In the rich pogonine fauna of the Mediterranean region which likewise includes normal 'pogoniform' species and 'syrdeniform' species the latter occur only at the sea shore. The history of the Australian pogonine fauna thus is strikingly different and once more it demonstrates the island-like structure of the Australian inland saline habitats that must have been isolated for a long period.

Acknowledgments

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Appendix

Checklist of the recorded species of Pogoninae from Australia

Pogonus australis Chaudoir	s.WA, VIC
Pogonus cardiotrachelus Chaudoir	s.WA, VIC, s.QLD
Pogonus diplochaetoides Baehr	c.WA
Pogonus fenelli Hudson	s.WA
Pogonus gilesi Moore	c.SA
Pogonus grossi Moore	c.SA
Pogonus hypharpagioides Sloane	c.SA, w.VIC
Pogonus matthewsi sp. nov.	c.SA
Pogonus nigrescens Baehr	ne.QLD
Pogonus perovalis sp. nov.	c.SA
Pogonus saskiae Baehr	c.SA
Pogonus sumlini Baehr	n.WA
Pogonus variabilis Moore	n.QLD, n.NT, n.WA
Pogonus vicinus sp. nov.	c.SA
Pogonus zietzi Sloane	c.WA, c.SA
Syrdenoidius spinipes gen. nov., sp. nov.	c.SA

THE SIGNIFICANCE OF WHALES TO THE ABORIGINAL PEOPLE OF SOUTHERN SOUTH AUSTRALIA

PHILIP A. CLARKE

CLARKE, P. A. 2001. The significance of whales to the Aboriginal people of southern South Australia. *Records of the South Australian Museum* 34(1): 19–35.

Aboriginal people in the coastal region of South Australia had a broad relationship with whales. This is reflected in their hunting and gathering economy, mythology and totemism, and with their historical interaction with the first Europeans who arrived to hunt the whale. This paper provides a cultural geographical view of Aboriginal associations with whales.

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Introduction

The importance of whales to both Aboriginal people and Europeans had an impact upon the nature of their relationship on the frontier of British expansion into South Australia in the early nineteenth century. In earlier times, coastal Aboriginal people feasted upon stranded whales, which also had significance as totemic ancestors to some groups. In the Lower Murray region, whales were the mythological source of their ability to make fire. After official European settlement in 1836, many Aboriginal people were involved directly and indirectly in whaling activities. To Europeans, whales were the basis of an industry that they hoped would help the Colony of South Australia to develop and prosper. In the developing Australian colonies, the whaling establishments were in need of manual labour, which Aboriginal people sometimes supplied. The first Europeans recognised the skill of Indigenous hunters, sometimes employing them as harpooners and whale spotters. As a region, southern South Australia is defined in this paper as the whole of the coastal zone and the surrounding temperate parts of the state.

Sources

The present study is part of a series of papers by the author that considers the historical and mythological relationships between Aboriginal people and the southern South Australian landscape (Clarke 1995, 1996, 1997, 1998, 1999a, 1999b). Europeans recorded the information upon which it is based from Aboriginal people who had lived in the southern districts prior to and during the early phases of European colonisation in South Australia. The material available consists of the observations from Europeans involved in the colonial process. The German missionaries, Christian G. Teichelmann, Clamor W. Schürmann and Heinrich A. E. Meyer actively recorded the culture of the local Aboriginal people. Their publications were essentially studies of Aboriginal language and religion (see Teichelmann & Schurmann 1840; Teichelmann 1841; Meyer 1843, 1846; Schurmann 1844, 1846). The records of William D. Wyatt (1879) from the late 1830s came from his official investigations into the admissibility of Aboriginal evidence in court.[1] Richard Penney was involved in the welfare of Aboriginal people in the Encounter Bay district. Later sources, such as George Taplin (Journals; 1874; 1879), acknowledged the first recorders, such as Meyer, as major sources of primary data. These observers had a practical interest in Aboriginal religion and traditions, in spite of the fact that their records were compiled before the development of anthropological theory. From them the early relationship between Europeans and Aboriginal people can be interpreted.

During the twentieth century, with the development of scientific methods with obtaining anthropological data, much additional

[1] Quarterly Report (1 October to 31 December 1837) from Wyatt to the Colonial Secretary, dated 1 January 1838 (Colonial Secretary Reports, 1838/3 & 1838/69, Public Records Office, Adelaide).

ethnographic material was collected from southern South Australia. Norman B. Tindale (1937, 1938, 1974, 1986, 1987), the Curator of Anthropology at the South Australian Museum, published the results of his fieldwork with the descendants of Aboriginal 'tribes' in southern South Australia.[2] The social anthropologists, Alfred R. Brown (1918), Ronald M. Berndt and Catherine H. Berndt (Berndt 1940; Berndt & Berndt 1993) recorded Aboriginal culture and traditions in this region. The twentieth century ethnographic sources are essentially attempts to record a pre-European culture, as it would have been lived by the generations preceding that of their informants. The popular accounts of southern South Australian mythology by Charles P. Mountford and Ainslie Roberts were chiefly based on the published records of Tindale. A more detailed analysis of the chief historical sources used in this paper is given elsewhere (Clarke 1994: 63–81, 417–425; 1995: 145–146; 1999a: 52–53).

Pre-European Practices

The coastline of South Australia is part of the migration route of the southern right whale (*Eubalaena australis*) from the Southern Ocean. Occasional strandings of whales were events that attracted many Aboriginal people for feasting. Daisy Bates recorded that the Wanmaring local group at the Head of the Bight in western South Australia had 'occasional gorges in large fish food, dead whales and other large sea creatures being found after some great storm'.[3] Aboriginal people considered that they had an active role in some strandings. For example, songs were used by 'strong men' of the coastal Lower Murray groups to 'cause' whale strandings (Tindale 1974: 18, 23–24, 80).[4] People from surrounding areas converged on the dead whale, being called by the aroma of a stranding, if not the messages sent out. In the Aboriginal languages around Adelaide and Encounter Bay the whales of all species were collectively called *kondoli*.[5] Tindale records another term for them that referred to their water blowing. Tindale says:

> The whales which frequented the shores off the mouth of the Murray River and the rocks at Encounter Bay where they often came close in shore were called *winkulare*, literally the 'whistlers' or 'blowers' from the intransitive verb *winkulun* 'whistle' because of their 'blowing'. Magical spells designed to entice the whales ashore were practised by the 'clever' men.[6]

For the Lower South East of South Australia, there is a transcription of a whale song in the 'Booandik' language (Smith 1880: 139). This was translated as 'The whale is come. And thrown up on land.' These lines were repeated over and over, perhaps to induce a stranding.[7] Evidence from elsewhere in Australia, such as the rock art around Sydney in New South Wales, suggests that coastal Aboriginal people had a keen interest in whales.[8]

Aboriginal people of the whale descent group at Encounter Bay believed that some of them could 'sing' whales in towards the shore or out, by standing on a rock and singing some 'wordless chant'.[9] Tindale (1937: 107, 112) recorded a whale song, in the Ramindjeri dialect

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[2] Tindale's journals, field notebooks, and the 'Milerum' manuscript are also important ethnographic sources. This material is housed in the Anthropology Archives, S.A. Museum.

[3] 'The Passing of the Australian Native. The Wanmaring Group (Head of the Great Australian Bight).' D. M. Bates manuscript collection at the Barr-Smith Library in Box 12/Section XIII/Part 6b.

[4] Aboriginal people claimed in the early 1980s that an elderly Ngarrindjeri person living at Point McLeay, who had recently died, knew how to 'sing a song to bring in whales'. Also in the early 1980s, some elderly Ngarrindjeri informants knew that there was a myth concerning whales and fire, but had forgotten the details (audiotape of the Cameron family talking at Kingston South East with P. G. Jones, S. J. Hemming & P. A. Clarke, 23 April 1983, Anthropology Archives, S.A. Museum).

[5] In the Adelaide area, whales were termed 'con-dol-ley' (Williams 1839 [1840: 295]), 'kondolli' (Teichelmann & Schürmann 1840 2: 12) and 'condollee' (Stephens 1889: 498). For the Lower Murray dialects, the name for whale is recorded as 'kondarli' by G. Taplin (1879 [1874]; 1879) and F. Taplin (Point McLeay Letter Books, 1879–84, p.98), 'kondolle' (Wyatt 1879: 170), 'kandarli' (Howitt 1904), 'kondolly' (M. Wilson in 'conventional mission script' [Tindale 1930–52: 161–165]), 'kondolly', 'kondal' (Tindale 1934–37), 'kondoli' by Tindale (1937), 'kondali' (Mountford & Berndt 1941), 'kondole' by Mountford and Roberts (1969) and 'kondili' by Berndt and Berndt (1993). This paper uses 'Kondoli' as a standard term for the Whale Ancestor.

[6] Tindale ('Milerum' manuscript, stage A, no.3, Anthropology Archives, S.A. Museum).

[7] After European settlement, Aboriginal people of the South East of South Australia also had a popular song about the 'whale fishery' at Rivoli Bay (Stewart n.d. [1977: 65–66]).

[8] Whales are major elements in the rock art in the Sydney area. At least one site appears to show a feast around a stranded whale (Campbell 1899: 46–47, pl. 24, fig. 1; Stanbury & Clegg 1990: 22–23, 54, 80–83, 113, 119). In September 1790, Tench (1793 [1996: 134]) records the feasting of a stranded whale which was 'in the most disgusting state of putrefaction' in the Sydney region. Kingston (1876: 277–278, 327) gives a related account from north of Sydney.

[9] *The Mail* newspaper, 19 August 1932. There are recent accounts recorded by Bell (1998: 320) concerning Aboriginal people formerly using whales for transport, although these are unsupported by the historical record.

of the northern end of Encounter Bay, to send whales away.[10] This was sung by a man of the *kondoli nga:tji,* or whale descent group, in order to assist a female whale and calf escape the shallow waters of Encounter Bay.[11] In this account, other people who were 'evil-minded', desired the whales to be stranded so that *kraipunuk* or oil could be collected for 'spear poison', perhaps as a sorcery material used against people who had the whale as their totemic familiar or *nga:tji.* Tindale stated:

> A man who had the whale as totem would not eat whale. If a whale became stranded on the coast, he would give permission for others to use it as food, but he himself would merely rub himself with the oil which it produced. If he saw a whale floundering off the shore, he would sing a magical song, telling the whale to avoid the shallows and escape to the sea.[12]

Tindale stated that to decorate themselves the men of the Warki and Tangani groups of the Lower Murray region would be ruddled with red ochre and whale oil.[13] Elsewhere in southern South Australia, it is also likely that whales were considered to be totemic beings, although apart from the Lower Murray region, the available early ethnographic data is slim.

The whale was associated with the Latalindjera descent group, which received its name from the place, Latang, at Hindmarsh River near Victor Harbor at Encounter Bay (Berndt & Berndt 1993: 311). To the south of Encounter Bay, Kondilindjarung ('whale, place-name marker') was a death place for whales, where one or two often beached themselves during the winter months (Berndt & Berndt 1993: 81, 103, 320, 326–327, 342, 565). It is situated on the Younghusband Peninsula on the seaside, south east of the Murray Mouth but north west of Noonamena. It was claimed that Kondilindjarung was where the people of this group and their associated beings, the whales, attempted to return before death. The Coorong ocean beach was renowned for its whale remains. Tindale records that:

> On the ocean beach one might be the inhabitant of another world, composed of sand, sea, spume, and giant whale bones. The scattered bones of blue whales lie here and there along the beach, for this is a graveyard where the great circumpolar current impinges upon the shores of Australia and casts up its burden of flotsam.[14]

According to the Berndts, Kondilindjarung is in the Kondilindjera descent group territory, believed to be an offshoot of the Ramindjerar, but who spoke Tangani instead. The relationship between the Kondilindjera and the Latalindjera descent group described by Tindale above is uncertain.[15] The presence of the Kondilindjera on the south eastern side of the Murray Mouth may well have been the result of a post-European adjustment in territory, as Taplin (1874 [1879: 2]; 1879: 34) recorded the Kondarlinyeri as a 'clan' based on the north western side of the Mouth. Kondarlinyeri was said to mean 'belonging to whales' (Taplin 1879–84: 98). Brown (1918: 252) provided evidence that suggests that there were no 'Kandarlinyeri'. He stated 'I was told by the natives that Kondarlinderi (the place of the whales) is merely the name of a part of the country occupied by Pankinderar clan, and that there is no clan of this name (Brown 1918: 252).'

During his fieldwork, Brown (1918: 240) considered it too late to obtain detailed information on the totemism of the Yaraldi people. Nevertheless he claimed:

> The men and women of a clan might eat, and did eat, their totem, if it were edible, but they were careful to destroy all the remains (bones etc.), lest they should fall into the hands of an enemy and be used for evil magic. Some part of the totemic animal was in some instances used as a badge of the clan. Thus the Liwurinderar used to carry pelican skins on their spears when they went out to fight (Brown 1918: 241).

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[10] See Tindale (1931–34 (1): 252–253) for notes of 'Kondoli Tungar or Whale Song of the Ramindjeri tribe at Encounter Bay, Song 14'.

[11] Tindale inscribes a draft typescript version of his paper with 'much of the song data given verbatim as dictated by Milerum'. Here it is stated that the whales were swimming in 'white sand water'. Other details include that the whales were 'mother' and 'son' and that whale 'slime' or oil was required to rub on their bodies with red ochre as a base for poison (copy in E. H. Davies papers, AA309, Accession no.1, Anthropology Archives, S.A. Museum).

[12] Tindale, *The Advertiser* newspaper, 14 May 1936. The symbolic importance of whales may be reflected in the rock art of the Sydney area, which depicts people inside whales. Stanbury & Clegg (1990: 22–23) suggest that this might be explained by the eastern seaboard practice of sick people lying inside the body of a stranded whale.

[13] Tindale ('Milerum' manuscript, folder 1, draft A. Anthropology Archives, S.A. Museum).

[14] Tindale, *The Advertiser* newspaper, 12 May 1936.

[15] Tindale (Lower Murray Totems Chart, miscellaneous papers, Anthropology Archives, S.A. Museum) links together the descent groups of Kondolinyeri (Taplin 1874 [1879]), Kondarlinyeri (Taplin 1879), Kandarl-inyeri (Howitt 1904), and Karagarindjeri [equivalent to Kondolindjeri] (Tindale ms). He does not list the Latalindjera.

This account is consistent with Meyer's claim that the *nga:tji* was a 'friend', 'countryman' or 'protector' (Meyer 1843: 86; 1846 [1879: 198]) and Taplin's definition of it as a 'tribal symbol' or 'tutelary genius' (Taplin 1874 [1879: 1, 63–64, 134]). The Berndts also record that some people were able to eat their *nga:tji*. Regarded as the flesh of the Kondilindjera, the members of this Lower Murray group alone could make the first cut on a beached whale carcass (Berndt & Berndt 1993: 81, 103, 320, 326–327, 342, 565). Other groups would wait until they had eaten.[16] The spirit of Kondoli departed through Kondilindjarung, leaving its meat for its 'brothers'. In this area, Aboriginal people possessed a pre-European system giving certain groups rights and privileges to the resources of the sea (see Peterson & Rigsby 1998).

The Kondilindjera responded to a whale stranding by sending messengers with invitations to neighbouring groups to come in for a feast on whale blubber, *pailpuli*, and meat, *mami*.[17] Normally, the coastal districts were sparsely populated during the wintertime (Tindale 1938: 21; 1974: 61–62; Clarke 1994: 182–183). The cutting of the flesh and blubber was performed with flint knives, *maki*. Aboriginal people cooked the fat before it was eaten and the oil was rubbed on their bodies for protection against the weather. The *witjeri*, leaves of the pigface (*Carpobrotus rossi*), were used as a relish with the meat. Ceremonies were held during the nights of the feast. The site of the stranding was not left until all the blubber was eaten. Aboriginal people used the ear bones as drinking containers and water storage vessels.[18] Aboriginal midden material collected from Moana, a sand dune area near the mouth of Pedlar Creek south of Adelaide, by Tindale in the 1920s contains sperm whale teeth and dolphin vertebrae.[19] This suggests that Aboriginal people had eaten beached whales and dolphins. Also, in the Rivoli Bay area, south of Encounter Bay, whales were also sometimes stranded. Aboriginal people called this place Weirintjam or Wilitjam, which Tindale claimed meant 'place of whales' from the Potaruwutj word 'weirintj', a whale.[20] It was a place noted by Tindale's informants for the whales that became stranded there, providing big feasts for the local people.

It is unlikely that Aboriginal people in South Australia were able to use their watercraft, built for calm water conditions, in killing small whales.[21] For marine animals stuck in shallow water or stranded on land, killing was a more straightforward task. Nevertheless, hunting across the open sea was limited. For instance, Ramindjeri people swam or travelled on rafts to West Island, which is less than a kilometre off the coast south west of Victor Harbor, to kill sea lions (*Neophoca cinerea*) and fur seals (*Arctocephalus fosteri*) (Tindale 1941: 241). They also travelled to Pullen Island on rafts in calm weather for sealing.[22] Most distant islands, such as Kangaroo Island, were places beyond the range of Aboriginal hunters immediately prior to European settlement (Clarke 1996, 1998). There is no evidence to suggest that Aboriginal people actively hunted whales or dolphins.

Whales In Aboriginal Mythology

The earliest written account of whale mythology in South Australia was by C. Teichelmann in 1840, presumably recounted by Aboriginal people who lived in the Adelaide area (see Amery 1998: 219, 224). He records:

> When the lark and the whale were men, they fought against each other. The lark speared the whale twice in the neck. The whale, finding itself sorely wounded, made its escape, jumped from pain into the sea, became a whale and spouted through the two wounds water to heal them; but in vain, till this day.[23]

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[16] Bates (1985: 197–198) records that the *mammang borungur* or whale totem people of Cape Leewin in the South West of Western Australia also ate the flesh of stranded whales, in spite of the fact that this was not the practice of people from other totems.

[17] Wyatt (1879: 170) claimed that Encounter Bay people also called whale blubber 'kondolle'.

[18] South Australian Museum specimen A49445; container made from a whale ear bone, collected from Pelican Point on the Coorong, donated by Mrs O. T. Cleggett, 1940s.

[19] Ross (1984: 19–41) provides an overview of the archaeological investigations based at Moana. This material would be less than 6,000 years before present, when the coastline of present-day Adelaide was largely formed. The sperm whale teeth found in Moana 'Site C' may have come from a multiple stranding, as they are from at least two individuals, one young and one old specimen (C. Kemper, pers. com.).

[20] N. B. Tindale (Geographic Place Names Cards & Potaruwutj Vocabulary Cards, Anthropology Archives, S.A. Museum). Tindale thought that the variation in the place name, Wilitjam, is probably relatively modern.

[21] In contrast, Aboriginal hunters in northern Australia had more access to the sea through their use of dugouts and outriggers gained through contact with Macassans and Torres Strait Islanders. For a description of their watercraft, see Haddon (1913), Tindale (1926: 103–112) & Baker (1988).

[22] See also Tindale (Wunindjeri clan entry in 'Clan Data' folder in 'Milerum' manuscripts, stage 2 Anthropology Archives, S.A. Museum).

[23] *South Australian Colonist* newspaper, 7 July 1840.

The same corpus of whale mythology appears to have been shared by the Adelaide and Encounter Bay peoples, perhaps reflecting Aboriginal movements around the time of European settlement in the early nineteenth century. In a Ramindjeri account of the myth, whales are connected with the origin of fire (Meyer 1879: 202–204). Here, it was believed that once long ago, all the Ramindjeri people gathered to dance at Mootaparinga (Cut Hill, along Hindmarsh River).[24] They did not have a fire, so they had to dance all day and it was hot. Their perspiration dripped down and became the large ponds there, and hills and valleys formed through the buckling of the ground caused by the stamping of their feet. Eventually, they sent for Kondoli, a large and powerful man who possessed fire. He came, but hid his fire. This made the Ramindjeri angry. Another Ancestor, Riballi, threw a spear at Kondoli, hitting him in the neck.[25] The commotion this caused transformed most of the people there into different animals, such as fish and birds. Kondoli himself rushed into the sea and ever after blew water out of his wound. Riballi took Kondoli's fire and placed it in a grasstree (*Xanthorrhoea* species), where it can be removed by using the dried flower stems as fire-sticks.[26]

The series of accounts recorded by Tindale in the twentieth century provide details that were not part of Meyer's account. In May 1934, Tindale received a Ramindjeri version of the Kondoli myth from Frank Blackmoor (Tindale 1930–52: 161–165; 1934–37: 181–184).[27] Here, Kondoli was a big man who possessed fire that fell from his body as he danced. He came to participate at a Ramindjeri ceremony. Kuroldambal the Owl argued with Krilbalil (= Krilbali) the Lark about who was to spear Kondoli to get the fire. Kuroldambal, who had large eyes, wanted Krilbalil's spear to use, as his eyes were too small to see properly. But when the dancing was close enough, Krilbalil grabbed his spear and struck Kondoli at the back of the head, making the fire fall out. Krilbalil grabbed the fire and placed it amongst grasstrees, causing the scrub to burn. People now had access to fire. Kondoli dived into the ground, eventually coming out and going into the sea.

Tindale recorded a version of the 'Story of Kondoli' from Milerum, a Tangani speaker, in May 1936 (Tindale 1934–37 vol.2: 232–235). In this account a 'tribe' that was part Mereldi (Murray River people), part Ramindjeri and Yoltindjeri (= Joltindjeri) planned to have a *molkaldi* type ceremony at which all participants would perform. Messengers were sent out in all directions and people gathered at Mutabaringga (= Mootaparinga), a site on the largest bend of the Hindmarsh River. The dancing area was at a flat on top of a range that had a depression. Kondoli, who was a big man, was camped at Brown Hill. He carried the flint with which fire could be made.[28] A 'river man' (Murray River person) called Ratunangi, the Robin Redbreast Bird, was there. Seven or eight Teiwuri (Brown Treecreeper) women from a local group, who greatly desired Ratunangi, grabbed him.[29] Relatives among the 'river people' grabbed their weapons and a fight with spears and waddies (clubs) took place. Firesticks were also thrown through the air.

To escape the fight, Kondoli fled towards the sea down Hindmarsh Valley, carrying his flint. He also had pieces of granite, which he dropped as boulders along the creek. At the site of Gay Bridge, Port Elliot (Kandeining) he took a boulder out into the sea. After returning and heading a little further inland he rested before diving into the sea at Kantjoar, where there is a swamp.[30]

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[24] Colonists used Mootaparinga (or Murtaparri) in the 1830s as the name for the mouth of Hindmarsh River at Encounter Bay (Wade cited Gouger 1838: 25; Mann cited Gouger 1838: 39, 42; Teichelmann & Schürmann 1840 2: 75). In the Adelaide language Mootaparinga reputedly means 'brackish water' (Robinson 1975: 44). If so, then it appears to be a term from a language north west of the Lower Murray. Adelaide terms, such as *murta* ['excrements of animals'], *parri* ['river'] and *-ngga* [grammatical 'in'] (Teichelmann & Schürmann 1840 1: 22; pt 2: 25, 38, 76) appear relevant, possibly translating as 'animal manure water, place of'. Tindale ('Myths' folder in 'Milerum' manuscript collection, Anthropology Archives, S.A. Museum) says 'Mutabaringga' is known by Europeans as Cut Hill.

[25] The 'Riballi' of Meyer is probably his rendering of 'Krilbali', the brown skylark.

[26] The use of fire is a major element of the Waiyungari mythology (Clarke 1999b). Bell (1989: 321–322, 427) speculates that whales are of special significance to Aboriginal women due to the link with fire and through associating the protective nature of whales over their calves with human child-care responsibilities.

[27] Yaraldi man, Mark Wilson (Thalrum or Thralrum), wrote the original text using conventional mission script. Tindale then annotated it by working directly with Frank Blackmoor, a Yaraldi man of the Piltindjeri descent group. Although Tindale refers to the Skylark as 'Krilbalil', I prefer the form 'Krilbali', as written by other authors and as recognised by some contemporary Ngarrindjeri people (see foot note 44).

[28] The flints were struck whilst being held in a dry pad of fungus, *kumpalatingi* (Mountford & Berndt 1941: 342–344).

[29] Tindale (1934–37: 233) records that as a result of what happened then, 'today you always see him [Ratunangi, Robin Redbreast] with seven or eight wives'.

[30] According to Tindale (Geographic Place Names Cards, Anthropology Archives, South Australian Museum), Kantjoar is a site in the Ngurunderi myth were he urinated (*kaindji* = urine).

From here, Kondoli went west along the shore, sometimes walking and other times swimming in water for safety. He walked between Granite Island and the shore, looking back to see if the others were following him. When Kondoli reached Wunangg, the mouth of the Inman River, he saw his friend Yamakawi rushing down the Inman towards him.[31] The 'wild men' were chasing Yamakawi for his firestick, made of *ngalaji* (dried flower stem of the grasstree), that he carried. Although Kondoli had eluded his first pursuers, he had to flee again, this time with Yamakawi. Kondoli went a little way into the sea and turned into a whale. There is a reef there today and the spray that rises with the waves is the whale spout, which represents smoke. Yamakawi went into the sea at Narailkang, near Waitpinga, and turned into a shark with big teeth.[32] For some time, people on the land had no fire as Yamakawi had taken away the *ngalaji*. Kondoli did not go far away as he had left something back at his camp. The people 'sang' (charmed) him into the shore, where they jumped on him and took his flint so that they could make fire. They also grabbed Yamakawi's firestick, which had been used as a back fin.

In another of Tindale's records, Kondoli the Whale man chased the Shark man who had stolen Kondoli's fire-making equipment, *wintjimi*, comprised of flint and pyrites.[33] This occurred at Spring Mount, which was called Mutabaringga, said to mean 'sacred magic doctor's place'. The hill represents Kondoli, who later became a whale. A big hole at the summit was said to be the 'blow hole' of the whale. Kondoli chased the Shark man to Brown Hill, called Kondolanangg.[34] From here Kondoli in anger rushed towards the sea in pursuit of the thief. Kondoli was transformed into a whale at Elliot Beach, called Kandeining, which was translated by Tindale's informants as 'from here'.[35] The Shark man was transformed into the whale's enemy, the shark, who retains the fire flints as teeth in his mouth. Tindale linked this account to the name of the south western spur of the Brown Hill, Nangge-we:ke, which he claimed means the 'stolen sun', referring to the stealing of fire.[36] In what appears to be a related account, Tindale stated:

> One of the myths of the area tells how there was contention between a man of the whale totem and another, the shark, for possession of the fire flints, without which the whale could not use his pyrites. At the climax of the story the men became animals and the shark fled taking with him the flint stones which were transmuted into his teeth.[37]

These versions place emphasis on the origin of fire relating to conflict between Ancestors, involving the Whale and Shark.

Tindale recorded other elements of the 'Fire myth' in the Warki language of the Goolwa area. Mutabaringga or Cut Hill was one of the homes of the whale man, Kondoli.[38] According to Tindale it was derived from *muturi* (sacred), *bari* (river) and *-ingga* (at).[39] Kondolinggara or Mount Jagged was where Karilbali (= Krilbali) fought with Kondoli for the possession of fire, wounding him. The place-name was reputedly derived from *kondoli* (whale) and *nggaran* (to assault or wound).[40] Kondolanang (= Kondolanangg or Brown Hill), where Kondoli emerged from the ground, was said to mean 'refuge of whales', derived from *kondoli* (whale) and *nangare* (refuge or shelter).[41] In another version, Kondoli, after being wounded by Karilbali:

> set fire to the country. Hiding first at this place [Kondolanang] he [Kondoli] fled to Kandeining

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[31] According to Tindale (1934–37: 232–233), Yamakawi was related to Kondoli, their hunting grounds adjoined. The quartz stones that Yamakawi left behind when he fled were used for making the jags on spears. Some of these were given to Yamakawi, after he became a shark, for his use as teeth (Tindale 1934–37: 234). Tindale writes 'Yamakawi' as 'Jamakawi'.

[32] Tindale ('Myths' folder in 'Milerum' manuscript collection, Anthropology Archives, S.A. Museum) claims that Yamakawi was the White Pointer Shark being who lived at Inman Hill.

[33] Tindale (Geographic Place Names Cards & 'Milerum' manuscript, stage A, no.3. Anthropology Archives, S.A. Museum). This is presumably a Ramindjeri version of the myth. Tindale claims that Mootaparinga is erroneously ascribed to Hindmarsh River by Cockburn (1908: 58).

[34] See also Tindale (Wunindjeri clan entry in 'Clan Data' folder in 'Milerum' manuscripts, stage 2. Anthropology Archives, S.A. Museum).

[35] N.B. Tindale (Geographic Place Names Cards, Anthropology Archives, S.A. Museum). Informants not named.

[36] This place name is the Nangawooka of Tite, which Tindale (Geographic Place Names Cards, Anthropology Archives, S.A. Museum) claims Cockburn (1908: 63–64]) incorrectly translates as 'place of springs'. Informants not named. See also Tindale (Wunindjeri clan entry in 'Clan Data' folder in 'Milerum' manuscripts, stage 2, Anthropology Archives, S.A. Museum).

[37] N. B. Tindale (no date) 'Strike-a-lights, Fire Flints'. Tindale collection, miscellaneous papers, Anthropology Archives, S.A. Museum.

[38] Data recorded by Tindale ('Aboriginal Placename Cards', Warki Language, AA338, Anthropology Archives, S.A. Museum) from the Yaraldi informant, Albert Karlowan (Karloan) and the Tangani informant, Clarence Long (Milerum).

[39] The derivation of '*muturi*' (sacred) here seems less likely than as '*murta*' (animal excrement) [see footnote 23].

[40] Data recorded by Tindale ('Aboriginal Placename Cards', Warki Language, AA338, Anthropology Archives, S.A. Museum). Informants not named.

[41] Data recorded by Tindale ('Aboriginal Placename Cards', Warki Language, AA338, Anthropology Archives, S.A. Museum) from the Yaraldi informant, Mark Wilson (Thalrum or Thralrum) and the Tangani informant, Clarence Long (Milerum).

where he entered the sea as a whale. There a shark being stole his fire flints. A wide spread story.[42]

After entering the sea, the fire flints were then stolen by Ngarakkani (= Ngarankani) the Shark being and the property of fire making was transferred to grasstrees and wood.[43]

In 1934 Tindale recorded an account, 'Story of the Stealing of Fire by the Whale' from Mark Wilson in the Yaraldi language.[44] Here, all the birds and animals, who were then human, met for a ceremony at Mutabaringga. Only Kondoli the Whale possessed fire; he guarded it jealously. Krilbali the Lark and another unnamed bird quarrelled over who should steal it. Kondoli was speared in the head by Krilbali and leaped into a cave on the hill before the fire could be taken from him. The Whale emerged in the deep water at Victor Harbor that is close to the beach and extends to Granite Island. The steam coming from Kondoli's wound was like that coming out of an earth cooking-oven, showing that there was fire inside. The whale still blows its steam out and stranded whales are quite hot, compared with other marine animals which are cold. In the sea, the Shark stole fire from the Whale and gave it to the birds, who were unable to control it and set fire to the country. The raging fire entered the trees, which means that they would now readily burn if set alight. Fire also entered the flints on the ground. Many of the birds got burnt, such as Tuta the Scarlet Robin being who had his breast burnt bright red. After the fire died, people discovered how to make fire from splitting grasstree sticks and rubbing them together and also by striking flints against ironstone pieces.

The anthropologists, Ronald and Catherine Berndt, also provided a record of the Kondoli mythology in the Encounter Bay district (Berndt & Berndt 1993: 16, 118, 235–236, 341–342, 450–451).[45] The Hindmarsh River area at Victor Harbor is associated with the Whale Ancestor and the origin of making fire with flints, *maki*. The flints were obtained from the Ramindjeri hills people. In the Berndts' version, many people attended a dance meeting held at Kondilinar, which is inland. When Kondoli the Whale Ancestor danced, sparks came from inside him, which excited the onlookers who were at that time without fire. Krilbali the Brown Skylark and Retjurukuru the Wagtail planned to spear Kondoli whilst he was dancing, to get his fire. Krilbali speared him deep in the back of his neck. Then Krilbali grabbed some of the fire that gushed out of the wound and fled with it. The people assembled there laughed, but Kondoli, Ngarankani (Shark), Mulori (Stingray) and Pungari (Seal) jumped into the water and came out at Latang, near the coast at the mouth of Hindmarsh River.[46] The Berndts (1993: 311) stated that Latang meant 'place of spearing'.[47] The Whale stayed at Balgolin (Pultung, Victor Harbor).

One of the Berndt's chief informants for the Kondoli mythology was the Yaraldi speaker, Albert Karloan, from the Manangka descent group. He told the Berndts that the spear thrown at the Whale Ancestor had entered the back of the neck, penetrating as far as the jaw. It was the jaw that produced the sparks. Karloan claimed that when the Whale was speared, the fire that fell on the ground at Kondilinar turned to flints, *maki*, which could be used to make fire. Flints could be also found where the Skylark had dropped them whilst running all over the country. The method of the transference of the fire from the Whale Ancestor to humanity is different from Meyer's earlier account, when a fire-stick made from a grasstree flower stem was used.

The Mountford and Roberts (1969: 40–41) version has details that appear as poetic adjustments to the main recordings. Fire was needed here because the dancers required light to dance at night. The large and powerful Kondoli was the sole owner, but hid the fire. After Kondoli was speared, the people at the ceremony were transformed into animals, such as kangaroos, possums, birds and fish. Kondoli, as the largest man, became the largest animal, the whale. Ngarrindjeri writer, David Unaipon, wrote a story

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[42] Data recorded by Tindale ('Aboriginal Placename Cards', Warki Language, AA338, Anthropology Archives, S.A. Museum). Informants not named. The derivation of Karilbali is here and on other cards recorded as 'magpie-lark being' instead of 'lark', but this clearly an error. See end note 44.

[43] Data recorded by Tindale ('Aboriginal Placename Cards', Warki Language, AA338, Anthropology Archives, S.A. Museum). Informants not named.

[44] Tindale (1930–52: 48, 91, 272–273). In this account, Tindale incorrectly identifies Krilbali as the magpie lark (*Grallina cyanoleuca*). From other sources, including contemporary Aboriginal informants, this term refers to the skylark (*Alauda arvensis*) (Brown 1918: 242; Berndt & Berndt 1993: 235–236, 311, 450–451, 461–462).

[45] The Berndts write 'Kondoli' as 'Kondili'.

[46] Many of these Ancestors became *nga:tji* of Ramindjeri clans surrounding Victor Harbor (Berndt & Berndt 1993: 311). *Ngarankani*, shark, was the *nga:tji* of the Ngarakerindjera descent group, based at King Point. In the Tjirbruki mythology he was speared and become the gummy shark (Tindale 1987: 9). *Krilbali*, brown skylark, was the *nga:tji* of Krilbalindjera based near Kondilinar. *Pangari*, seal, was the *nga:tji* of the Ratalwerindjera at Middleton.

[47] Berndts (1993: 311) claimed that Latang was equivalent to 'Yalla-doola' as listed by Wyatt (1879: 179).

about Wondangar the Whale and Goon na Ghun the Starfish Ancestors.[48] Although some Ngarrindjeri words are used in the text, the inclusion of a lyrebird, which is a species not found in South Australia, suggests it was intended as a generalised eastern states account.

There are whale mythologies in other parts of southern South Australia that bear some resemblance to the Kondoli myth. The existence of the Whale Ancestor as a land-based person appears widespread. Schurmann recorded in the Adelaide Plains region that:

> Nganno – travelled far and wide, seeking the murderers of his son, Gurltatakko, and while travelling named the country as we know it today. After killing the murderers he went home but his tribesmen on seeing him panicked and ran in fear into the sea where they were transformed into sea creatures. He told them not to do it but they responded 'I am a shark', 'I am a whale' etc. Nganno turned himself into a sea monster at the end (Schurmann Journals, 21 August 1839).

It is interesting to note that many of the terms and place-names used in the Lower Murray versions above are derived from the Aboriginal vocabulary of Adelaide. In the Tjirbruki mythology of Gulf St Vincent and western Encounter Bay, some of the Ancestors ran into the sea to become species of shark (Tindale 1987: 9). The language used in this account recorded by Tindale is a mixture of Adelaide and Lower Murray vocabulary.

Stealing the ability to make fire is a common theme in the mythology of Aboriginal Australia. There are other accounts that appear structurally similar to the Kondoli myths discussed above, but do not involve whales as one of the primary Ancestors. For example, in a version of a Western Desert myth recorded by Tindale, the Turkey Bustard Ancestor kept fire to himself and fled south towards the Southern Ocean at Eucla to place the flints under the water.[49] The Hawk Men rescued the flints, which are accessible today only at low tide on calm days. Similarly, Smith (1880: 18–20) records that the Booandik people between Mount Gambier and MacDonnell Bay in the South East of South Australia believed that fire was once the sole property of Mar the Cockatoo, and was hidden on his head. At a meeting, people argued over how to find out more about Mar's fire. Several people attempted to spy on Mar making the fire. As a result, Tatkanna the Robin Red Breast had his chest singed red from the heat of Mar's fire. When fire was at last caught in a grasstree stick, it spread to the grass and dry underwood where it started a bushfire. Mar rushed to where the others were camped and a fight started. One of those there, a large man named Kounterbull, received a deep spear wound in the back of his neck. He rushed into the sea where, as a whale, he was afterwards to be seen spouting water from his wound. In Western Victoria, Crows had fire and the Fairy Wren and Hawk stole it (Dawson 1881: 54). In the West Coast district of South Australia, Aboriginal people possibly perceived whales as having a more sinister character. In the Mirniny language, whales were called *muburn kailgaburdi*, with *muburn* (or *moburn*) recorded as 'devil'.[50] Tindale claimed that there 'are several versions of the [fire] story extending as far to the west as Perth and to the Tanganekald on the Coorong.'[51] He cites the record of Grey (1839: 76) from the South West of Western Australia that lists *maad-jit-teeyl* as a 'magic stone' of the shark. Tindale also provided an account from the Murray Basin where a small species of hawk stole an ember from the shark as he was entering the sea and placed it for safe keeping in a grasstree.[52] The similarity of the events in widespread accounts of this myth, along with the variety of language chosen by the informants to communicate them, make it difficult to determine the origin and range of the whale myths.

The Kondoli mythology of the Lower Murray has important cultural insights into both methods of fire-making. The use of fire-sticks in what is referred to as the rotation method is widespread across Australia. Tindale describes this process in the southern regions:

> Fire making is practised using a dry grasstree flower stalk, the 'male', twirled into a split section of the same stalk, in which usually a notch has been cut. This is the 'female'. Tinder is placed below the

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[48] Unaipon, no date (Davis *et al.* 1990: 33–52).

[49] N. B. Tindale (no date) 'Strike-a-lights, Fire Flints'. Tindale collection, miscellaneous papers, Anthropology Archives, S.A. Museum.

[50] D. M. Bates, 'Native Vocabulary, Eucla District', Barr Smith Library, University of Adelaide (box XII, 2A 4–5). According to Bates the shark appears to have been called by a related term, *kailga-kailga*. Similarly, the porpoise was *kailga-ailga* and the trapdoor spider was *kailga wurdi*.

[51] Data recorded by Tindale ('Aboriginal Placename Cards', Warki Language, AA338, Anthropology Archives, S.A. Museum). The informants are not named. Tindale (1930–52: 273) lists Grey 1839 as a record relating to the Kondoli fire myth.

[52] N. B. Tindale (no date) 'Strike-a-lights, Fire Flints'. Tindale collection, miscellaneous papers, Anthropology Archives, S.A. Museum.

notch which supplements the hot powdered pith engendered by the rotary process. When a spark appears it is deftly transferred to a ball of dry, teased grass or other easily ignitable matter.[53]

In the same reference, Tindale added that fine stone grit was sometimes placed in the female part of the apparatus to help fire-making by increasing friction. The use of percussion methods to make fire, generally by striking flint, together with 'ironstone' or iron pyrites, has been recorded in some parts of South Australia. In the Coorong region, Tindale's Tangani informant, Milerum, told him that flint, *marti*, was used for fire-making and came by way of trade from south of Cape Jaffa.[54] The flint was used by striking it across iron pyrites, *baruke*, that came from the Mount Lofty Ranges at a place called Whale Hill, just to the north of the western boundary of the Tangani speakers. Powdered sun dried kangaroo dung, fungus, bark and sandalwood scrapings were used as tinder (*narn*) and kept wrapped in possum fur. Although this method of fire-making was rarely recorded, Charles P. Mountford and Ronald M. Berndt (1941: 343–344) use the Karloan version of the Kondoli myth as proof that the percussion method existed in Australia before Europeans arrived. The Tjirbruki mythology of the Adelaide plains also mentions the use of iron pyrites in making fire (Tindale 1987).

European Settlement

In the first few months of the official British settlement of South Australia in 1836, Encounter Bay came under scrutiny as a possible site for the capital of South Australia. The large harbour and the proximity of a supposed navigable entrance to the Murray River were major factors in its favour. Nevertheless, it was Encounter Bay's suitability for whaling activities that started settlement there. Captain John Hart, who was familiar with the South Australian coast through his whaling and sealing activities during the early 1830s, was consulted by the South Australian Colonisation Commissioners in London (Blacket 1911: 431).[55] Whaling was the first official industry in the Colony of South Australia. Two 'shore' whaling stations were set up in Encounter Bay in 1837 – a group from Sydney headed by Captain Blenkinsopp and the other controlled by the South Australia Company.[56] The former was situated at Police Point (now Victor Harbor), and the latter at the foot of the ridge connecting Rosetta Head (now The Bluff) with the hills. Other stations were later set up at The Nob (now Port Elliot) and on Granite Island. In the case of the whaling establishments at Police Point and Granite Island, these were considered to be of 'lesser importance' and soon abandoned (Newland 1921: 16).

Maritime archaeological and historical studies have produced a list of whaling stations across the coast line of South Australia (Angas 1847a, text for plate XVI; Hosking 1973, legend: 2; Kostoglou & McCarthy 1991, Table 1, p.67). There were large whaling stations situated in Encounter Bay at Rosetta Head (1837 to 1855) and Freeman Nob (about 1840). On Kangaroo Island there were establishments at Hog Bay (1841 to 1844) and D'Estrees Bay (1843 to 1844). There were also smaller whaling stations at the mouth of the Onkaparinga River (from 1841 to about 1843) and at Fishery Cove near Cape Jervis (from 1842 to the early 1850s). Several establishments were present on the West Coast of South Australia at Thistle Island (1838 to 1839), Fowler Bay (1840s), Saint Peter Island (1840s), Streaky Bay (1843 to 1846) and Trial Bay (1845). In the South East of South Australia, there was the Rivoli Bay Station (1830s intermittently to the 1880s).

Two species of whale were commercially hunted in southern South Australia, the sperm or cachalot whale (*Physeter macrocephalus*) and the southern right whale (*Eubalaena australis*).[57] There were two distinct seasons for European whaling, referred to as 'in-shore' and 'off-shore'. The 'in-shore season' was during winter, with the southern right whales caught as they travelled along the coast of south eastern Australia from Tasmania (Fig. 1). This was known as 'bay whaling'. The 'off-shore season' aimed to catch

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[53] N. B. Tindale (no date) 'Strike-a-lights, Fire Flints'. Tindale collection, miscellaneous papers, Anthropology Archives, S.A. Museum.

[54] N. B. Tindale (no date) 'Strike-a-lights, Fire Flints'. Tindale collection, miscellaneous papers, Anthropology Archives, S.A. Museum.

[55] In 1831, Captain Hart left a sealer at Baudin Rocks in the South East of South Australia (Kostoglou & McCarthy 1991: 63). After official British settlement in 1836, Hart became a successful merchant and politician in South Australia. He was Premier of the colony on three occasions (Blacket 1911: 431–432).

[56] 'Report on Whaling in South Australia' (1841 [reprinted in *Proceedings of the Royal Geographical Society of Australasia, South Australian Branch*, 1921: 15–20]) and Cameron (1979: 23). Newland (1936) gives a fictional account of whaling in the region in 'Paving the Way.'

[57] For descriptions of South Australian whaling practices refer to 'Report on Whaling in South Australia' (1841 [1921]), Hosking (1973, explanatory note: 1), Glover & Ling (1976), Whitelock (1985: 61, 64), Kostoglou & McCarthy (1991: 1–2) and Judd et al (1992: 13–14).

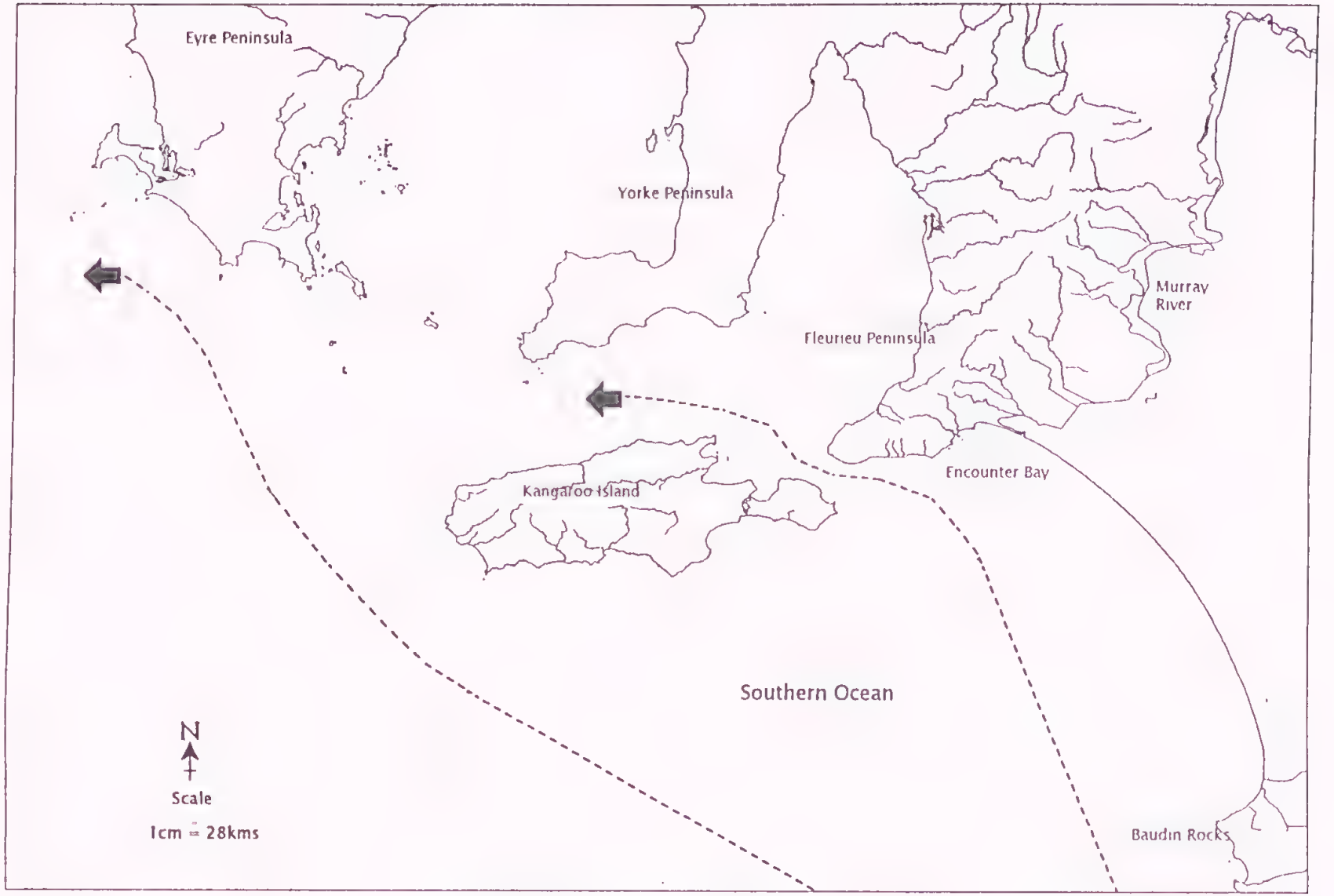

FIGURE 1. The possible winter migration routes of the southern right whale.

whales as they were returning from the west about 320 kilometres off the coast beyond the continental shelf. Sperm whales were generally only caught offshore, although, as with other whale species, they occasionally stranded along the coast. The 'off-shore' whaling was more expensive than 'bay whaling', as deep-sea activities required bigger boats. Whitelock (1985: 63) states that from 1836 to the end of 1840, 536 barrels of southern right whale oil, 158 barrels of sperm oil, and 655 bundles of whale bone were exported from Encounter Bay to London via Hobart.

Impact Of Whaling Upon Aboriginal People

European whalers operating in South Australian waters utilised Aboriginal labour, being cheaply available when required (see Clarke 1996, 1998). For instance, it was reported in an Adelaide newspaper in 1839 that:

> We are rejoiced to hear that the fishery at Encounter Bay is proceeding most prosperously, nearly 300 tons of oil having been already obtained. A fact connected with it has been communicated to us which is of an interesting and not unimportant nature. It appears that a boat is employed in the fishery which is entirely manned with natives. They take their part in the occupation equally with the white men, and are found to be not less expert than they. If the aboriginal inhabitants are competent to this laborious species of employment, what should prevent them being rendered efficient in many other paths of industry.[58]

Furthermore, in 1846 Aboriginal people manned a boat run by Barton at Encounter Bay.[59] In the 1830s, the Kangaroo Island sealers knew an elderly Aboriginal man called Kondoy (Condoy), who was described as being a 'tribal chief' and apparently lived at Cape Jervis.[60] It is possible that this man's name referred to the whale. Since Kondoy was a senior member of his descent group, he may have taken on the identity of their main *nga:tji*, a whale. The sealers were part of a seafaring population originating in various Northern Hemisphere and Pacific countries. They and their Aboriginal wives were engaged in various enterprises that were reliant on passing vessels, such as gathering salt, growing vegetables and the hunting wallabies, kangaroos and seals for their skins. On the frontier, the whalers and sealers were opportunistic. They were also the first direct contact that Aboriginal people had with Europeans. For example, in May or June 1838, whalers on the *Elizabeth* were blown ashore at the north end of Rivoli Bay (Stewart n.d. [1977: 78–79, 89]). They set up a station there, which attracted Aboriginal people looking for food. On at least one occasion these whalers rowed out in a boat to Penguin Rock with Aboriginal women, who caught for them the fat birds after which the islet was named. Similarly, Davies (cited Tindale 1986: 235) recorded a song in the Wirangu language that records the careening of a whaling boat at Denial Bay in the West Coast of South Australia.

From the outset, the whaling station at Encounter Bay attracted large numbers of Aboriginal people. Gouger (1838: 53) claims that the establishment of the whale fishery at Encounter Bay had made this area a favourite residence of Aboriginal people during the whaling season (presumably referring to the winter time). Penney noted this seasonal movement in November 1840, when he observed Aboriginal people leaving Encounter Bay and heading east. Penney reports:

> I found the natives going or preparing to go to the Lower Murray. The natives of the Lower Murray tribes usually return at the end of the Whaling season, accompanied by some of the Encounter Bay tribe, to their stations on this river ...[61]

Leigh (1839: 163–164) describes how upon the capture of a whale, the local Aboriginal people came to the stations for feasts. A painting by George French Angas shows whalebones being used as the framework of an Aboriginal hut at the Encounter Bay whaling stations (Fig. 2). Cameron (1979: 4) suggests that the whalers encouraged local Aboriginal people to camp around the whaling station by distributing whale-meat and rum, so that the white men had access to Aboriginal women. In the 1840s, Richard Penney and David Wark treated Aboriginal people

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[58] *The Southern Australian* newspaper, 1 August 1839.

[59] *The South Australian Register* newspaper, 8 August 1846. Aboriginal involvement in the whaling industry is noted elsewhere in Australia during the 1840s, with Aboriginal whalers present at Twofold Bay in southern New South Wales (Davidson & Davidson 1988: 25–34).

[60] See Thomas (1925: 45–46) and Clarke (1998: 39). Also see *The Advertiser* newspaper, 27 December 1886. An elderly Aboriginal man named 'Konday' is a character in Cawthorne's 'Kangaroo Islanders' (Cawthorne 1854 [1926: 110–111]).

[61] Transcript of a letter from Penney to the Governor of South Australia, 7 January 1841. (Group 787; 1841, no.8 – AA309, Stirling collection, Anthropology Archives, S.A. Museum).

FIGURE 2. Aboriginal people living in camps on the edge of the Encounter Bay whaling stations used whale bones to make their shelters (G. French Angas watercolour, 1844 [lithograph version published in Angas 1847b, plate LVI]).

suffering from small pox and venereal diseases at Encounter Bay (Jenkin 1979: 46–49). Penney was concerned about the ill treatment of Aboriginal people by whalers. Of the Encounter Bay people, he said:

> There are many individuals of this tribe, who have been content, whilst there was any employment, to live for months at the fisheries, and to do the work of whalers; and one was, the last season, rated amongst the crew of the chief headsman, Thomas, being considered as a good a hand as many of the white people.[62]

The German missionary, Heinrich A.E. Meyer, operated a school for Aboriginal people near the whaling station.[63] The Lower Murray people living there were among the colony's first Aboriginal 'fringe dwellers', although at this stage they were essentially opportunistic rather than dispossessed.

At the Encounter Bay whale fishery, it is claimed that Aboriginal men were employed to cart blubber to pots where Aboriginal women boiled it up in vats (Cameron 1979: 39).[64] Payment was usually made in gin and tobacco. The whalers employed at least one Aboriginal man, named Charlie Warner, as a 'spotter'.[65] He was a member of the Kondoli clan and it was said that Warner could also sing the whales to come in or to go out. The whalers believed in his abilities, paying him with rations. On one occasion, Warner did not receive his payment through an oversight. Sustie Wilson, an Aboriginal whaler, claimed:

> So Charlie Warner ran out to a rock near the sea, and began his chanting. A huge whale which was lying in the bay vanished in a few seconds. The

[62] Penney, *The South Australian Register* newspaper, 21 November 1840.

[63] Penney mentions a 'Rev. Mr Myers of Encounter Bay' [= H.A.E. Meyer] who was 'improving the natives' and studying their language (*The South Australian Register* newspaper, 26 June 1841).

[64] The origin of the historical source for this reference is not clear.

[65] *The Mail*, 19 August 1932.

> whaling crew dashed out, but could not even find the wake which is usually left by the whales. They returned, and went to old Charlie, and give him his rations. He said, 'Now you catch him. You go back same place this afternoon. You catch him all right.' The same afternoon, they found the whale in the same place. I often saw him bring whales into the bay, as well.[66]

Aboriginal men, such as One Arm Charley, Peter and Encounter Bay Bob, had experience in the whaling and sealing industries, dating back to before official European settlement (see Clarke 1991: 98–100; 1996: 56–59; 1998: 37). After 1836, when European colonists arrived at Encounter Bay, these men became important agents employed by the Europeans as trackers, guides and translators.[67]

In the second half of the nineteenth century, some Aboriginal men were still engaged as whalers (Taplin Journals, 5 May & 22 July 1861). In 1932 an Aboriginal whaler, Sustie Wilson, claimed that many of the whalers from the 'Encounter Bay tribe' were much better than the Europeans. He was reported to have said that this 'was because they had been throwing spears all their lives, and took to harpooning naturally.'[68] Throughout the whaling industry, the use of Indigenous harpooners seems to have been the practice with some teams.[69] During the operation of the whale fishery on Granite Island, Aboriginal people were employed to take wood and drinking water out to the island along a connecting reef during low tide (Hodge 1932: 124). Whaling was hazardous employment. For example, when Sustie Wilson was still quite young and working in a whaling crew, their boat was dragged about nineteen kilometres out to sea by a huge whale. Sustie claimed that it 'took two days and two nights to row back ... it was hard going too, especially when the wind was against us. Not many of the young men of today could have done it.'[70]

Transactions between Europeans and Aboriginal people did not always occur freely. During the 1837 season, a European named Driscoll was travelling on a 'native pad' overland from Encounter Bay to Adelaide when he was murdered by 'waddy' (club) near Hindmarsh Valley by his Aboriginal guide, Reppindjeri, known by Europeans as 'Elic' (Cameron 1979: 4, 28, 39–42; Jenkin 1979: 52–55; Castles & Harris 1987: 11–13).[71] This had resulted from a quarrel over Driscoll's apparent refusal to pay for sex with one of Elic's two Aboriginal women. The slain man was a whaler with Captain Blenkinsopp. Although the Aboriginal people involved kept the circumstances quiet, a local Aboriginal woman, Kalinga, who Europeans called 'Sarah', leaked the facts. She was the wife of a Kangaroo Island sealer and whaler, Walker. Reppindjeri was arrested by Walker and imprisoned by authorities for some months on the *South Australian* moored near the Bluff, before he allegedly escaped and disappeared.

Some Aboriginal people in the Lower Murray area apparently considered that there was an advantage in working with European colonists. At Encounter Bay in the 1840s Penney stated that:

> The Encounter Bay natives have been properly brought up, they have never been accustomed to get anything, without working for it, and this has not only made them more industrious, but also made them pay that attention to the instruments and proceedings of Europeans, that renders them almost equal to them as general labourers.[72]

This integration into a European pattern may well have been due in part to the disruption of hunting and gathering practices through European occupation of the land. Tindale blames early settlement by the whalers for loss of knowledge of indigenous place-names amongst Aboriginal people. He states:

> Since occupation of much of the western head waters of the two rivers [Hindmarsh and Inman] had ceased after the early visits of white whalers, the names of places there never learned [by his Aboriginal informants].[73]

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[66] *The Mail* newspaper, 19 August 1932.

[67] See Pullen's account (*The South Australian Register* newspaper, 15 August 1840) of the investigations, involving the assistance of these three men, over the massacre of the *Maria* wreck survivors.

[68] *The Mail* newspaper, 19 August 1932.

[69] In the fiction of 'Moby Dick or The Whale', the main harpooner, Queequeg, was a Maori man (Melville 1851).

[70] *The Mail* newspaper, 19 August 1932.

[71] The 'native pad' was a feature of the Aboriginal landscape that Europeans started to use. Meyer (1843: 52) refers to an Aboriginal song about 'a fine road ... winding between the hills' between Encounter Bay and Willunga. This was possibly the trail that Watts Newland and his party were taken on when two Aboriginal people guided them from Adelaide to Encounter Bay in 1839 (Robinson 1975: 21). In the case of the Encounter Bay track, this was originally just over half a metre wide, and so its use by Europeans was initially confined to foot and horse traffic (Sweetman 1928 [1988: 4]). Eventually, however, it was widened for use by coaches.

[72] *The Examiner* newspaper, 28 January 1843.

[73] Tindale (Wunindjeri clan entry in 'Clan Data' folder in 'Milerum' manuscripts, stage 2. Anthropology Archives, S.A. Museum).

The pre-European culture of the northern parts of the Lower Murray region was, by the twentieth century, poorly known due to early European settlement there (see Clarke 1994: 58, 227–231, 241–242).

At Encounter Bay, Aboriginal people adapted to the new situation, quickly gaining skills in a wide range of European practices. Penney claimed:

> that many of them can use the axe and the saw, and have been employed in cutting posts and rails for fencing, and two or three can drive bullock-drays; they are all of them very useful in tracking cattle and horses – they are very good hands in a boat, and in diving – and they have rendered great services to owners of the wrecks at Encounter Bay.[74]

When a drowning occurred in the Encounter Bay and Lower Murray region, Aboriginal people invariably assisted in the recovery of the bodies (Linn 1988: 60).[75] Although Meyer ran an Aboriginal School at Victor Harbor (from 1840 to about 1846), Aboriginal people were relatively free to work for European colonists.[76] Encounter Bay people were frequent visitors to the Adelaide region in the 1840s.[77] Even with the establishment of the Point McLeay Aboriginal Mission in 1859, Aboriginal people in the Lower Murray region still moved around fairly freely.

Whaling declined in the early 1840s as gaslight in the Northern Hemisphere challenged the use of candles and oil lamps (Blainey 1977: 115). The use of whale oil declined further when kerosene from American oil wells became available (Hosking 1973, chap.2: 9, 32–35; Whitelock 1985: 66). The decreasing value of whale products led to the South Australia Company pulling out in 1842 (Cameron 1979: 23). By this time, European activities had already denuded much of the hills behind the whaling stations at Encounter Bay ('Baleineau', cited in Whitelock 1985: 65). Seasons of whaling continued sporadically up to the 1870s. In about 1870, whaling recommenced at Encounter Bay, after stopping in the 1860s (Hodge 1932: 127). For two seasons there was an Aboriginal crew on the whaling boats. Aboriginal labour became crucial to the colony at times when European labour was too expensive and scarce. Aboriginal people were considered suitable for employment that demanded heavy use of the body. Nevertheless, in 1871 only one whale was killed and towed to the Bluff Station (Whitelock 1985: 66). In the early twentieth century, Aboriginal people in the Lower Murray area were able, on at least one occasion, to actively hunt a whale. They killed a 5.6 metre female whale trapped near Rabbit Island in the Coorong system. Parts of it were dragged into a boat, cut up and distributed among the people at the Point McLeay Mission (Ely 1980).

Discussion

Versions of the Kondoli mythology establish that the main players were Ancestors and associated spirit familiars of various descent groups in the Encounter Bay area of the Lower Murray cultural region. Here, the whale mythology, although existing in many different forms, was used by Aboriginal people to explain the origin and making of fire. The involvement of particular bird ancestors and the shark vary widely across the corpus of this mythology. There are also parallels between these myths and others that do not involve the whale. In the coastal regions of southern Australia, the observation of whales spouting and the recognition of their warm bloodedness appear to have been major elements in the mythology. There is insufficient data for areas of coastal South Australia outside the Lower Murray to determine the totemic significance of whales, but there is an indication that whale strandings provided other coastal Aboriginal groups with occasional feasts of food. The records of who had access to the meat of stranded whales indicate that Aboriginal people had a system of determining ownership of food resources originating from the sea.

From the early nineteenth century, Aboriginal people were being incorporated into the world economy through their participation in the marine industries controlled from the Northern Hemisphere. European colonists used indigenous people as a cheap labour force. Aboriginal people in the Encounter Bay and Adelaide areas, through

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[74] *The South Australian* newspaper, 21 November 1840.

[75] On 12 December 1837, Aboriginal people dragged the two surviving members of Captain Blenkinsopp's exploration party from the Murray Mouth in a whaleboat (*The South Australian Register* newspaper, 20 January 1838; Gouger 1838: 42–45; Hahn 1838–1839 [1964: 130]; Hosking 1973, chap.1: 21–22; Cameron 1979: 4, 28). In June 1838 Aboriginal people from east of the Murray Mouth assist the survivors of the wrecked 'Fanny' to return to Victor Harbor (*The South Australian Register* newspaper, 25 August & 8 September 1838).

[76] Meyer left the Encounter Bay district in 1848 and settled at Bethany in the Barossa Valley (Cameron 1979: 48).

[77] *The Observer* newspaper, 27 April 1844.

their interaction with the sealers and whalers, were the first groups in South Australia to gain extensive experience of Europeans. Thus whaling at Encounter Bay provided the background to Aboriginal and European interaction during the British colonisation of South Australia.

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TAXONOMIC REVISION OF THE AUSTRALIAN LIZARD *PYGOPUS NIGRICEPS* (SQUAMATA: GEKKONOIDEA)

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Allozyme electrophoresis and analysis of scalation, colour pattern and body proportions were used to define species boundaries in the widespread, arid adapted legless lizard *Pygopus nigriceps*. Three species are recognised. *Pygopus nigriceps* (Fischer, 1882) is confined to the sandy deserts of central and western Australia. *Pygopus schraderi* Boulenger, 1913 inhabits mainly heavier soils and rocky substrates in the arid and semi-arid zones of eastern Australia. The third species is described as new, and occurs in the wet-dry tropics of northern Australia.

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Pygopods are a lineage of snake-like lizards endemic to Australia and New Guinea with evolutionary affinities to the geckoes (Kluge 1987; King 1990; Donnellan *et al.* 1999). There are 35 species of pygopods recognised, placed by most recent authors into eight genera (Kluge 1974, 1976; Wilson & Knowles 1988; Storr *et al.* 1990; Ehmann 1992; Cogger 1996). The genus *Pygopus* Merrem is considered (Kluge 1974; Cogger 1996) to comprise two species, *Pygopus lepidopodus* (Lacépède) which occupies the southwestern, southern and eastern margins of Australia, and *Pygopus nigriceps* (Fischer) which is widespread throughout the more xeric parts of Australia.

Kluge (1974) found considerable phenotypic divergence between populations of *P. nigriceps* from the western and eastern parts of Australia. They were separated by a narrow zone of character discontinuity located approximately along 135°E. In addition, he found that specimens from north of 18°S in Western Australia (WA) and the Northern Territory (NT) tended to be more like the eastern than the western form but Kluge had insufficient specimens to be able to identify the northern extension of the character discontinuity. He suggested that two subspecies be recognised, a western *P. n. nigriceps* and an eastern *P. n. schraderi* Boulenger, and that the northern specimens be treated as a taxonomically separate unnamed, problematical set.

Kluge's separation of *P. nigriceps* into two subspecies was continued by Storr *et al.* (1990) and Cogger (1996) who both ascribed the northern WA and NT specimens to *P. n. schraderi.* Wilson and Knowles (1988) suggested that northern populations were an intermediate form that could be tentatively regarded as undescribed. Ehmann (1992, 1995) provided two different interpretations for the status of *P. nigriceps*. In 1992, he suggested there were two separate species, *P. nigriceps* whose range he gave approximately as west of 135°E, including northern WA and the NT, and *P. schraderi*, whose range he gave approximately as east of 135°E including Cape York Peninsula. However, by 1995 he had altered this view and suggested there were two subspecies, *P. n. nigriceps* and *P. n. schraderi.* Their ranges were as he had suggested previously for *P. nigriceps* and *P. schraderi*, except that populations from northern WA and the NT were assigned to *P. n. schraderi* while those from Cape York Peninsula were not assigned to either subspecies.

In the present study, we have employed multilocus allozyme electrophoresis and morphology to examine the taxonomic status of *P. nigriceps* and to clarify species boundaries. This revision explicitly invokes the evolutionary species concept (Simpson 1951), the significant feature of which is that a species is a lineage evolving separately from others and with its own unitary evolutionary history and fate.

Materials And Methods

Specimens

For the allozyme analysis, frozen liver samples from the Australian Biological Tissue Collection (ABTC) at the South Australian Museum, Adelaide were used. The samples had been dissected from fresh specimens and stored continuously at –80°C. In all, liver samples from 43 specimens of *P. nigriceps* were available for analysis. In addition, liver samples from nine specimens of *P. lepidopodus*, chosen to cover the known range, were used to provide a sister lineage for the *P. nigriceps* species-complex, and as a check on the authenticity of the *P. nigriceps* samples. An incidental aim was to gain preliminary data on possible cryptic speciation, given the extensive range and known colour variations in *P. lepidopodus*.

There was the potential for a very large number of *P. nigriceps* specimens to be available for morphological analysis from the Australian state museum collections. We concentrated on specimens from north of the Tropic of Capricorn (23°26'30"S). All specimens whose liver tissues were examined in the allozyme study were examined for morphological characters, provided that the body was available for analysis, as were all specimens in the South Australian Museum collection and selected specimens from the other state museums. Museum registration numbers for all specimens examined electrophoretically and/or morphologically (n = 260) are given in the Appendix. Institutional acronyms follow Leviton *et al.* (1985).

Allozyme electrophoresis

Allozyme electrophoresis was conducted with liver homogenates on cellulose acetate gels (Cellogel, Chemetron) according to the methods of Richardson *et al.* (1986). Proteins and enzyme products of 35 presumed loci were scored. The enzymes and other products stained, abbreviations and Enzyme Commission Numbers are: aspartate aminotransferase (AAT, EC 2.6.1.1), aconitate hydratase (ACOH, EC 4.2.1.3), aminoacylase (ACYC, EC 3.5.1.14), adenosine deaminase (ADA, EC 3.5.4.4), alcohol dehydrogenase (ADH, EC 1.1.1.1), carbonate dehydratase (CA, EC 4.2.1.1), diaphorase (DIA, EC 1.6.99.?), enolase (ENO, EC 4.2.1.11), esterase (EST, EC 3.1.1.?), fructose-bisphosphatase (FBP, EC 3.1.3.11), fumarate hydratase (FUMH, EC 4.2.1.2), glyceraldehyde-3-phosphate dehydrogenase (GAPDH, EC 1.2.1.12), guanine deaminase (GDA, EC 3.5.4.3), (S)-2-hydroxy-acid oxidase (GOX, EC 1.1.3.15), glycerol-3-phosphate dehydrogenase (G3PDH, EC 1.1.1.8), glucose-6-phosphate isomerase (GPI, EC 5.3.1.9), β-glucuronidase (βGLUR, EC 3.2.1.31), L-iditol dehydrogenase (IDDH, EC 1.1.1.14), isocitrate dehydrogenase (IDH, EC 1.1.1.42), cytosol aminopeptidase (LAP, EC 3.4.11.1), L-lactate dehydrogenase (LDH, EC 1.1.1.27), lactoglutathione lyase (LGL, EC 4.4.1.5), malate dehydrogenase (MDH, EC 1.1.1.37), 'malic' enzyme (MDHP, EC 1.1.1.40), mannose-6-phosphate isomerase (MPI, EC 5.3.1.8), nucleoside-diphosphate kinase (NDPK, EC 2.7.4.6), dipeptidase (PEP-A, EC 3.4.13.?), tripeptide aminopeptidase (PEP-B, EC 3.4.11.?), proline dipeptidase (PEP-D, EC 3.4.13.?), phosphogluconate dehydrogenase (PGDH, EC 1.1.1.44), phosphoglucomutase (PGM, EC 5.4.2.2), superoxide dismutase (SOD, EC 1.15.1.1) and triose-phosphate isomerase (TPI, EC 5.3.1.1). For the genetic analysis, geographically proximate specimens of a single genetic type that is, where there were no fixed allelic differences, were pooled to form Operational Taxonomic Units (OTUs). On this basis, 25 OTUs of *P. nigriceps* were designated. Each of the *P. lepidopodus* specimens was treated as a separate OTU. The OTU localities are shown in Fig. 1 and composition in the Appendix. Evolutionary distances between OTUs were estimated with Cavalli-Sforza chord distances (Cavalli-Sforza & Edwards 1967) calculated with BIOSYS-1 (Swofford & Selander 1981). The Neighbour-joining (NJ) algorithm, implemented in PHYLIP version 3.5c (Felsenstein 1993) was used to build trees from these distances. The maximum parsimony (MP) criterion optimality was also used to recover phylogenetic trees with each locus considered as a character and each allele as an unordered character state. Polymorphic loci were encoded as uncertainties using this option for multistate characters in PAUP* version 4.0b3. (Swofford 1999). The data were bootstrapped to assess confidence for individual nodes.

Morphology

Kluge (1974) assembled a large character set for morphological analysis of the pygopods. Many of these characters are not applicable to the genus *Pygopus* and some are difficult to score in that they depend upon arbitrary starting points or locations on the body. Initially, we selected those

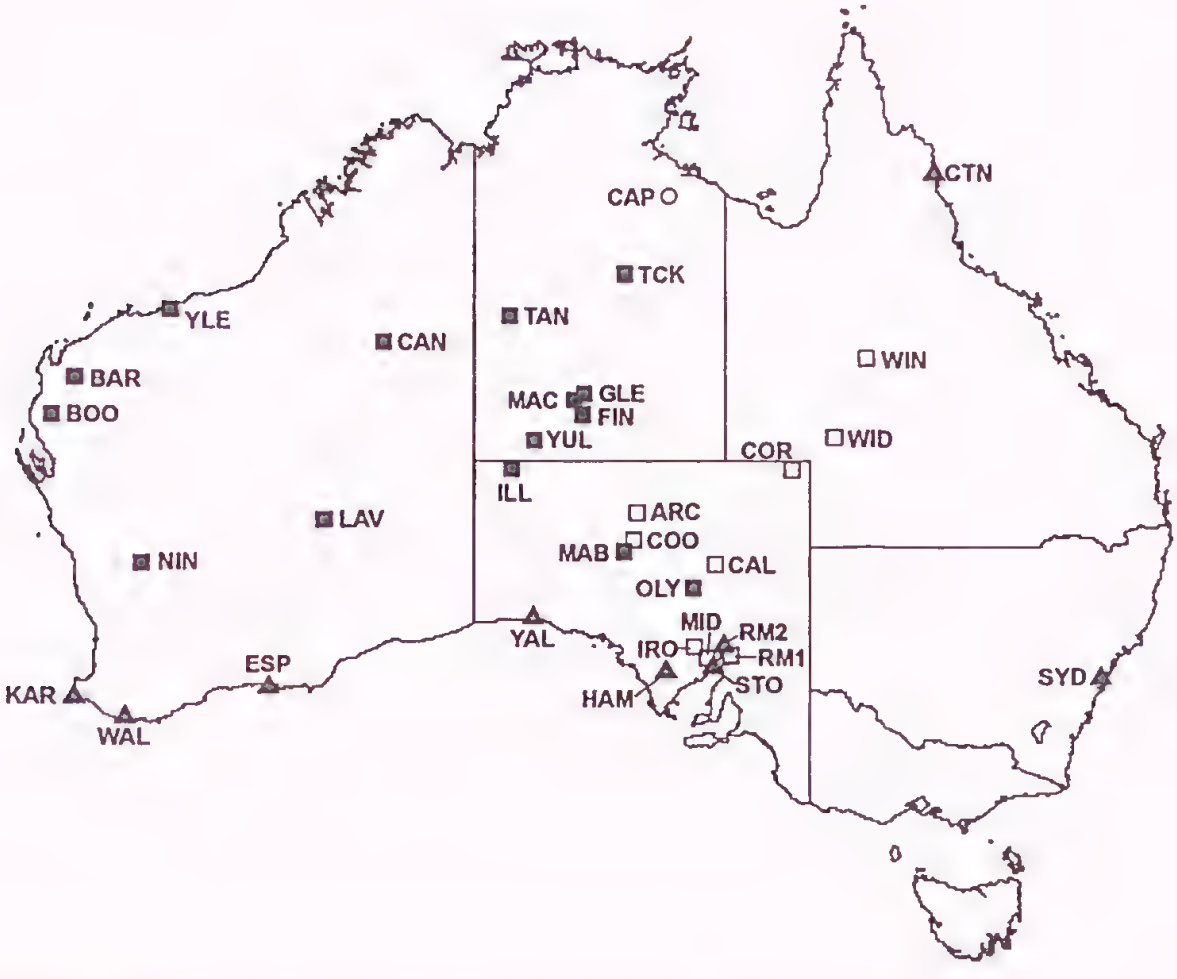

FIGURE 1. Map showing collection localities for the 34 *Pygopus* OTUs examined electrophoretically. See Appendix 1 for a key to the OTU labels. □ = 'eastern' group, ○ = 'northern' group, ■ = 'western' group, ▲ = *P. lepidopodus*.

characters reported by Kluge as varying significantly within *Pygopus* and were either quantitative in nature, or if qualitative, defined by unambiguous reference points. We added several new characters that seemed likely to be useful for taxonomic purposes. Measurements were made with vernier callipers to the nearest mm.

The characters and their abbreviations used in the morphological study are listed below. Where characters were defined by Kluge (1976), they are indicated by *; characters modified from those used by Kluge are indicated by #.

Subnostril scale# (SNS). The nostril may contact the first supralabial scale (0) or a thin strip of the nasal scale may separate the nostril from the supralabial (1). Kluge's 'subnostril scale' refers to the portion of the nasal underlying the nostril.

Ventral scales* (VS). The number of ventral scales between the posterior edge of the mental and the vent, including the preanal scale.

Orbital scales# (OS). The number of scales along the anterior margin of the bony portion of the orbit between the anteriormost and posteriormost enlarged supraciliary scales.

Dorsal scale keeling# (DSK). Keels absent (0), scales weekly keeled (1), or scales moderately keeled (2). The keeled scales were always unicarinate.

Dorsal scale row keeling (DSRK). The number of dorsal rows of scales exhibiting keeling.

Preanal pores* (PP). The total number of preanal pores.

Dorsal interorbital pattern# (DIP). Pattern on the dorsal surface of the head between the orbits. Varies from no significant pigmentation to a mottled appearance, not distinctly different from the snout, to the presence of brown or black pigmentation forming a faint to strongly contrasting dark bar. Scored as no significant pigmentation, not distinctly different from snout (0), mottled appearance not distinctly different from snout (1), brown or black pigmentation present as a faint bar (2), or

TABLE 1. Allele frequencies expressed as a percentage for 34 OTUs of *Pygopus* at 35 loci. Alleles are designated alphabetically, with 'a' being the most cathodally migrating allele. Where enzymes are encoded by more than one locus, the loci are designated numerically in order of increasing mobility. Sample sizes are given at the head of each column, except when fewer individuals were successfully typed. In the latter case sample sizes are indicated by the number in superscript beside the first allelic frequency entry for a locus. Where allele frequencies are not given, the OTU is fixed for the allele. The following loci were invariant: *Ca*, *βGlur*, *Ldh-1*, *Ldh-2*, *Lap*, *Mdh* and *Tpi*.

	'eastern'									'northern'						
Locus	WIN 1	WID 2	COR 1	COO 1	ARC 1	CAL 1	MID 1	IRO 1	RM1 2	CAP 3	TCK 3	TAN 1	GLE 1	FIN 1	MAC 2	YUL 2
Aat	a	a	a	a	a	a	a	a	a	a	d(17) c(33) b(17) a(33)	a	a	c(50) a(50)	c(25) a(75)	c(25) a(75)
Acoh-1	b	b	b	b	b	b	b	b	b	b	a	a	b(50) a(50)	b(50) a(50)	c(50) a(50)	b
Acoh-2	c	c	d(50) c(50)	c	c	b	b	c(50) b(50)	c	a	b(83) a(17)	b	b	c	b1	c(50) b(50)
Acyc	b	b	b	b	c(50) b(50)	c(50) b(50)	b	c	c(75) b(25)	d	b	b	b	b	b	b
Ada	a	a	a	a	a	a	a	a	a	b	b	b	b	b	b	b
Adh	a	a	a	a	a	b(50) a(50)	a	a	a	a	a	a	a	a	a	a
Dia	b	b	b	a	a	b	b(50) a(50)	b	b	a	c	c	c	c	c	c
Eno	b	b(50) a(50)	b	b	b	b	b	b	b	b	b(67) a(33)	b	b	b	b	b
Est	c(50)	b b(50)	b	b	b	b	b	b	b	b(83)	b a(17)	b	b	b	b	b
Fbp	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b(25) a(75)	a
Fumh	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b(75) a(25)
Gapdh	b	b	b	b	–	–	b	b	b	b	b	–	b	b	b	b
Gda	a	a	a	a	a	a	a	a	a	b(17) a(83)	b	b	b	b	b	b
Gox	b	b	b	b	b	c(50) b(50)	b(50) a(50)	c	b	c(83) b(17)	c(83) b(17)	c	c	c	c(25) b(75)	c
G3pdh	b	b	b	b	b	b	b	b	b	a	b	b	b	b	–	b
Gpi	a	a	a	a	–	–	a	a	a	a	a	a	a	a	a	a
Iddh	c	c	c	c	c	c	c	c	c	c	f	f	e	f(50) e(50)	–	f(50) e(50)

'western'									*P. lepidopodus*								
ILL 1	OLY 3	MAB 7	LAV 2	NIN 1	CAN 1	BAR 2	BOO 1	YLE 1	YAL 1	ESP 1	HAM 1	STO 1	SYD 1	WAL 1	KAR 1	RM2 1	CTN 1
c(50) a(50)	c(17) a(83)	c(36) a(64)	c(25) a(75)	a	a	a	c(50) a(50)		a	a	a	a	a	c(50) a(50)	a	a	a
–	b	c(25) b(75)	b	b	–	c(25) b(50)	b a(25)	b	c	c	c	c(50) b(50)	a	c	c	c	c
–	b	c(14) b(86)	c(25) b(75)	b	–	c(50) b(50)	b	c(50) b(50)	e(50) d(50)	e(50) c(50)	d(50) c(50)	d	c	d	d	d	c
–	b	b	b	b	–	b	b	b	b	b	b	b	b	b	b	b	a
b	b	c(7) b(93)	b	b	–	b	b	b	–	b	b	b	b	c(50) b(50)	c(50) b(50)	b	b(50) a(50)
–	a	a	a	a	–	a	a	a	a	a	a	b	a	a	a	b(50) a(50)	b
–	c	c	c	c	–	c	c	c	–	d	d	d	d	d	d	d	c
b	b(33) a(67)	b(86) a(14)	b	b	b	a	a	b	c	b	c	c	a	c	c	c	a
b	b	b	b	b	b	b	b	b	b	b	b(50)	b a(50)	b	b	b	a	b
a	a	a	a	a	–	a	a	a	b(50) a(50)	a	a	a	a	b	b	a	a
b	b(83) a(17)	b(86) a(14)	b	b	–	b	b	b	b	b	b	b	b	b	b	b	b
b	b	b	b	b	–	b	b	b	a	a	a	a	a	–	–	a	a
–	b	b	b	b	–	b	b	b	b	b	b	b	b	b	b	b	b
–	d(25) c(50)	d(22) c(57) b(25)	c b(21)	c	–	c(75) b(25)	c	–	b	c	b	b	c(50) b(50)	–	–	c	c
–	b	b[6]	b	b	–	b	b	b	–	b	b	c	a	–	–	b	a
a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b
f(50) e(50)	g(8) f(50)	f(25)[5] e(75) e(42)	f	–	–	f[1]	f	f	c	c(50) b(50)	b	c(50) b(50)	d	–	–	c	a

TABLE 1. (cont.)

	'eastern'									'northern'						
Locus	WIN 1	WID 2	COR 1	COO 1	ARC 1	CAL 1	MID 1	IRO 1	RM1 2	CAP 3	TCK 3	TAN 1	GLE 1	FIN 1	MAC 2	YUL 2
Idh-1	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a[1]	a
Idh-2	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Lgl	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Mpi	c	c(75)	d(50) b(25)	b c(50)	b	b	b	b	b	d	b	b(50)	b a(50)	b	b	b
Ndpk	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Pep-A		a	a	a	a	a	a	a	a	b(75)	b a(25)	c	b	b	c(50)[1]	b b(50)
Pep-B1		a	a	a	a	a	a	a	a	a	b	a	a	a	a[1]	a
Pep-B2	c(50) b(50)	b	b	d	e	b	d	d	d	c(50) b(33) a(17)	c	f(50) c(50)	c	c(50) b(50)	f(50) c(25) b(25)	c
Pep-D	c(50) b(50)	e(50) d(50)	e(50) a(50)	e	e	e	e	e	e	e(67) c(33)	g(17) f(83)	f(50) b(50)	g(50) f(50)	g(50) f(50)	f	g(25) f(75)
Pgm	a	a	a	a	a	a	a	a	a	a	a	a	a	a	c(25)	a a(75)
Sod	c	c	c	c	c	c	c	c	c	b	c(83) b(17)	c	c	c	c	c

brown or black pigmentation present as a strong bar (3).

Dorsal nuchal pattern* (DNP). The pattern on the dorsal surface of the head and neck immediately posterior to the parietal region varies in a similar way to the interorbital region. Scored as no significant pigmentation not distinctly different from snout (0), mottled appearance not distinctly different from snout (1), brown or black pigmentation present as a faint band (2), or brown or black pigmentation present as a strong band (3).

Orbital patch (OP). Dorsoventrally orientated darkly pigmented patch around and/or below the orbit extending to the supralabial scales and sometimes to the infralabial scales. Scored as absent (0), faint (1), moderately intense (2) or intense (3).

Narial patch (NP). Dorsoventrally oriented darkly pigmented patch or streak around and/or below the nostril extending to the supralabial scales and sometimes to the infralabial scales. Scored as absent (0), faint (1), moderately intense (2) or intense (3).

Contrast of lateral head pattern (LHP). Relative intensities of the orbital and narial patches may vary. Whereas some specimens or species show an equally intense development of both patches, others may have a noticeably weak expression of the narial patch (even absence) compared to the orbital patch. The converse (narial patch more strongly developed than orbital patch) was not observed. Scored as intensities of both patches equal (1), differing by one on the NP and OP scores (2), differing by two (3), or differing by three (4).

Snout-vent length* (SVL). The horizontal distance between the median anterior-most extreme of the snout and the median posterior-most extreme of the middle preanal scale.

These characters were scored for each specimen from which liver samples had been taken for

'western'									*P. lepidopodus*								
ILL 1	OLY 3	MAB 7	LAV 2	NIN 1	CAN 1	BAR 2	BOO 1	YLE 1	YAL 1	ESP 1	HAM 1	STO 1	SYD 1	WAL 1	KAR 1	RM2 1	CTN 1
–	a	a	–	a	–	a	a	a	–	a	a	a	b(50) a(50)	–	b(50) a(50)	a	a
–	b	c(7)	b b(93)	b	b	b	b	b	–	a	a	a	a	a	a	a	a
b	b	b(86)	b a(14)	b	–	b	b	b	b	b	b	b	a	–	–	b	a
b	b	b	b	c(50)	b b(50)	b	c(50)	b b(50)	b	b	b	b	b	b	b	b	b
b	b	b[6]	b	b	b	b	b	b	b	b	b	a	c	c	c	b	b
c(25)	c(33) b(75)	b[6] b(67)	b	b	–	b	b	b	b	b	b	b	b	–	b	b	a
a	c(83)	a a(17)	b(25)	c(50) a(75)	– a(50)	c(25)	b(50) b(75)	a a(50)	–	a	a	a	a	c(50)	a a(50)	a	a
c	c	f(21) c(79)	c	c	–	c	c	c	–	–	–	–	–	–	–	–	-
–	f	h(7) f(86)	g(50) e(25)	f	g e(7)	g(25) f(50) b(25)	g(50) f(50)	f e(25)	–	f(50) b(50)	c	b	f	f	e	b	f(50) c(50)
a	a	a	a	a	a	b(50)	a a(50)	a	a	a	a	a	a	a	a	a	a
c	c	c	c	c	c	c	c	c	a	a	a	a	a	a	a	a	a

allozyme electrophoresis, except for three 'western' specimens for which vouchers were not available for examination (ABTC 6588, 31799, 31812). For statistical comparisons of the morphological characters except SVL, the significance of differences between taxa was assessed with the non-parametric Mann-Whitney *U* test. For comparisons of SVL, unpaired Student's *t* tests were used after testing for departures from a normal distribution for each taxon (Shapiro-Wilks test) and pairwise tests of equality of variances (Levene test). All tests were two-tailed with an a set at 0.05 and were carried out with STATISTICA (Statsoft Inc. 1997).

Results

Table 1 shows the allelic profiles of the 25 OTUs of *P. nigriceps* and nine OTUs of *P. lepidopodus* for the 35 loci. These data were converted into matrices of percentages of loci showing fixed allelic differences (FD) and Cavalli-Sforza chord distances between OTUs (not shown). A fixed allelic difference occurs at a locus when the two samples under comparison share no alleles (Richardson *et al.* 1986). Richardson *et al.* (1986) argued that percentage of loci showing fixed allelic differences is an appropriate genetic distance metric for species boundary studies and is relatively unaffected by small sample size. We present a phenogram constructed from Cavalli-Sforza chord distances between OTUs by NJ (Fig. 2A). A heuristic search under MP found 77 335 equally most parsimonious trees of length 53 steps. A strict consensus of the equally most parsimonious trees with bootstrap proportions from 10 000 pseudoreplicates is presented in Fig. 2B. For the NJ and MP analyses adjacent populations between which there were no fixed allelic differences were pooled and allele frequencies recalculated, making

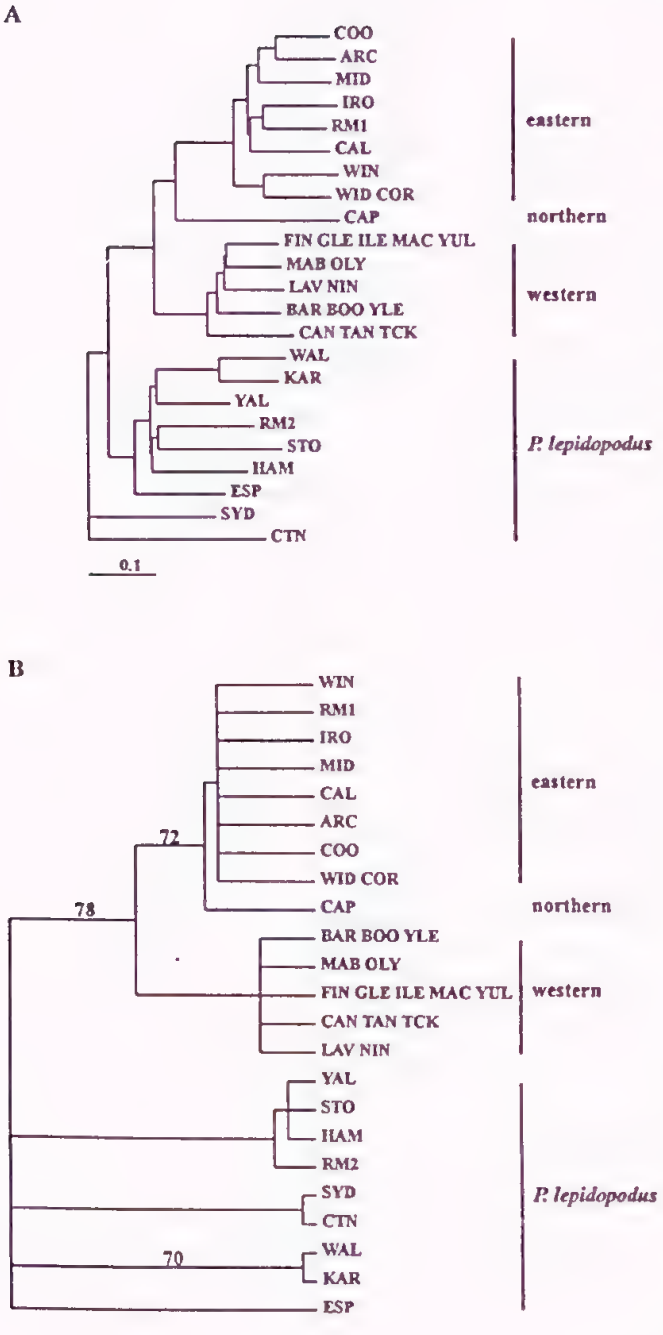

FIGURE 2. (A) A Neighbour-joining phenogram constructed from Cavalli-Sforza chord distances between OTUs; and (B) a strict consensus tree of more than 2000 equally most parsimonious trees found with a heuristic search. Bootstrap proportions >70% from 2000 pseudoreplicates are indicated to the left of relevant nodes.

a total of 14 OTUs within *P. nigriceps* for the final analyses.

The allozyme data (Fig. 2 and Table 1) show that the *P. nigriceps* OTUs are genetically more similar to one another than they are to any of the *P. lepidopodus* OTUs. Monophyly of the *P. nigriceps* OTUs received strong support (78%) from bootstrapping (Fig. 2B). The *P. lepidopodus* OTUs exhibit considerable genetic heterogeneity suggesting that more study is warranted.

Within *P. nigriceps*, both the NJ and the MP analyses are concordant in showing the presence of three lineages herein designated 'eastern', 'northern', and 'western'. However, strong bootstrap support (>70%) was found only for the monophyly of the 'eastern' lineage (Fig. 2B). The primary split between the *P. nigriceps* OTUs occurs at a minimum of 14% FD and broadly distinguishes two groups, an 'eastern' and a 'western' group. These two groups show diagnostic allozyme differences at four loci (*Ada, Dia, Gda* and *Iddh*) and other differences that are diagnostic for some of the OTUs between each group at eight loci (*Aat-2, Acoh-1, Acoh-2, Acyc, Fumh, Pep-A, Pep-B1* and *Pep-D*). There is genetic divergence within both the 'eastern' and 'western' groups with seven loci (*Acoh-2, Acyc, Dia, Gox, Mpi, Pep-B2* and *Pep-D*) displaying fixed allelic differences between one or more OTUs in the 'eastern' group and six loci (*Acoh-1, Acoh-2, Eno, Iddh, Pep-B1* and *Pep-D)* displaying fixed allelic differences between one or more OTUs in the 'western' group. The greatest intragroup genetic divergence, at an average of 10% FD, is between the OTUs WIN, WID and COR from central Queensland (Qld) and the 'eastern' group OTUs situated in the corridor between the eastern and western deserts. This may reflect the well-known climatic-ecological barrier of the Simpson Desert on patterns of speciation (Cracraft 1986, 1991).

None of the OTUs of the 'eastern' and 'western' groups were found in strict sympatry. However, 'eastern' and 'western' groups were found in regional sympatry, i.e. within 30–80 km of each other, in the Coober Pedy/Mabel Creek area (OTUs COO and MAB). Fixed allelic differences at six loci (*Ada, Dia, Gda, Iddh, Pep-A* and *Pep-B2*) were found between the two OTUs. Given the null hypothesis that two OTUs are sampled from a single population of eight individuals, the probability of not observing a heterozygote at the six loci showing fixed allelic differences can be derived from the Hardy-Weinberg equation as $(1-[2 \times 0.125 \times 0.875])^{6\times8} = 7.035 \times 10^{-6}$ (see Richardson *et al.* 1986 for a fuller explanation of this approach). Hence, the null hypothesis can be rejected and a reasonable alternative hypothesis is that two species are present in the Coober Pedy/Mabel Creek area.

A second split among the *P. nigriceps* OTUs occurs at a minimum of 21% FD and distinguishes

the 'eastern' and 'western' groups from a single 'northern' OTU, CAP. There are diagnostic allozyme differences between the 'eastern' and 'northern' groups at six loci (*Acoh-2, Acyc, Ada, G3pdh, Pep-B1*, and *Sod*) and between the 'western' and 'northern' groups at five loci (*Acyc, Dia, G3pdh, Iddh* and *Mpi*). In addition, there are other differences that are diagnostic for some of the OTUs between the 'northern' and other two groups at 11 loci (*Acoh-1, Acoh-2, Dia, Gda, Iddh, Mpi, Pep-A, Pep-B1, Pep-B2, Pep-D* and *Sod*).

The magnitude of the genetic differences encountered, the evidence of separate evolutionary histories of the 'eastern', 'western' and 'northern' groups and direct evidence of lack of gene flow between two of the lineages is sufficient to reject the null hypothesis of a single species within *P. nigriceps*. Consequently, we considered the groups as three separate species for the purposes of morphological examination. The 'eastern' and 'western' groups correspond roughly in geographic location with Kluge's (1974) suggested ranges for *P. n. schraderi* and *P. n. nigriceps* respectively. The 'northern' group comprises only one population in the samples available for electrophoresis thus preventing any delineation of its geographical distribution on allozyme data alone. These three groups proved to have a distinctive suite of morphological characters as outlined in the following analysis.

A summary of the variation in morphological characters is shown in Table 2 for the three groups. The data in Table 2 show that a suite of morphological features varies concordantly with the electrophoretic data. This table therefore provides the basic morphological characters for separating specimens into the 'eastern', 'northern' and 'western' groups.

The 'western' group is easily separated from the other two groups in that: the nostril is separated from the first supralabial scale by the nasal ('subnasal scale' present); dorsal scale keeling is absent; the mean number of ventral

TABLE 2. Morphological statistics for specimens of *Pygopus* for which allozyme data were collected. E = 'eastern' group, N = 'northern' group, W = 'western' group. See text for character abbreviations. $\bar{x}$ = mean, *S* = standard deviation, *R* = range, *n* = sample size, * *P* for two-tailed Mann-Whitney *U* or unpaired Student's *t* tests, tests for normal distribution[n] and equality of variances[v] were not significant. See Materials and Methods for the definitions of characters.

		Univariate Statistics			Pairwise Statistical Comparisons*		
Character	Group	E (*n*=11)	N (*n*=3)	W (*n*=26)	E/N	E/W	N/W
SNS	$\bar{x}$ (*S*)	0 (0)	0 (0)	1 (0)	0.88	<0.001	<0.001
VS	$\bar{x}$ (*S*)	110.3 (4.6)	109.7 (1.2)	130.8 (5.9)	1.0	<0.001	<0.001
	R	105–122	109–111	114–140			
OS	$\bar{x}$ (*S*)	9.18 (1.17)	10.7 (1.5)	11.8 (1.6)	0.17	<0.001	0.35
	R	7–11	9–12	10–16			
DSK	$\bar{x}$ (*S*)	2(0)	1(0)	0(0)	0.005	>0.001	<0.001
DSRK	$\bar{x}$ (*S*)	12.4 (0.8)	7.67 (1.58)	0 (0)	0.005	>0.001	<0.001
	R	12–14	6–9				
PP	$\bar{x}$ (*S*)	13.0 (1.2)	13.3 (0.6)	10.2 (1.1)	0.45	<0.001	<0.001
	R	12–15	13–14	8–12			
DIP	$\bar{x}$ (*S*)	0.45 (0.52)	0.33 (0.58)	2.32 (.80)	0.78	<0.001	0.004
	R	0–1	0–1	0–3			
DNP	$\bar{x}$ (*S*)	2.09 (0.83)	1.33 (1.15)	2.92 (0.28)	0.29	0.001	0.002
	R	0–3	0–2	2–3			
OP	$\bar{x}$ (*S*)	1.91 (0.70)	2.67 (0.58)	2.44 (0.71)	0.37	0.09	0.89
	R	1–3	2–3	1–3			
NP	$\bar{x}$ (*S*)	1.82 (0.60)	0	1.2 (1.04)	0.005	0.02	0.06
	R	1–3	–	0–3			
LHP	$\bar{x}$ (*S*)	1.09 (0.30)	3.67 (0.58)	2.24 (0.88)	0.005	<0.001	0.019
	R	1–2	3–4	1–4			
SVL	$\bar{x}$ (*S*)	147.6 (23.1)[n]	136.0 (7.9)[n]	156.1 (33.2)[n]	0.42[v]	0.45[v]	0.31[v]
	R	96–178	130–145	79–204			

scales is greater than 120; the mean number of preanal pores is less than 12; there is usually a well-developed blackish interorbital bar.

The 'eastern' group can be separated from the 'northern' group in that: The dorsal scales are moderately keeled with keeling occurring over ten or more rows in the 'eastern' group but weakly keeled over fewer than ten rows in the 'northern' group. The orbital and narial patches are present and are of moderate and equal intensities in the 'eastern' group, while in the 'northern' group the orbital patch is more strongly expressed than the nasal patch in any individual, and the nasal patch may be completely absent.

These characters were then used to separate the museum specimens for which tissues had not been available for allozyme electrophoresis. The great majority of specimens were readily separated (n = 251) but some difficulty was experienced in separating six 'eastern' and 'northern' specimens that had 'washed out' body patterns together with indeterminate scale keeling. The consistent allozyme and morphological differences between the three groups is sufficient for each group to be given species status. The 'western' group is *P. nigriceps*, the 'eastern' group *P. schraderi* and the 'northern' group *P. steelescotti* sp. nov. A map showing the geographic distribution of the three species is shown in Fig. 3. Note that the distributions of *P. nigriceps* and *P. schraderi* overlap in south-western Queensland (Qld), eastern NT and central and eastern SA; and those of *P. nigriceps* and *P. steelescotti* sp. nov. overlap in northern NT and WA; and all three species are found in eastern NT.

Once separated into the three species, the characters used in the morphological study on the electrophoresed specimens were scored. The results are summarised in the species descriptions given below. An additional character of Kluge, tail length, was added. It was measured as the horizontal distance between the posterior-most extreme of the middle preanal scale and the tip of the tail. Measurements were made only on those few specimens with complete and unregenerated tails.

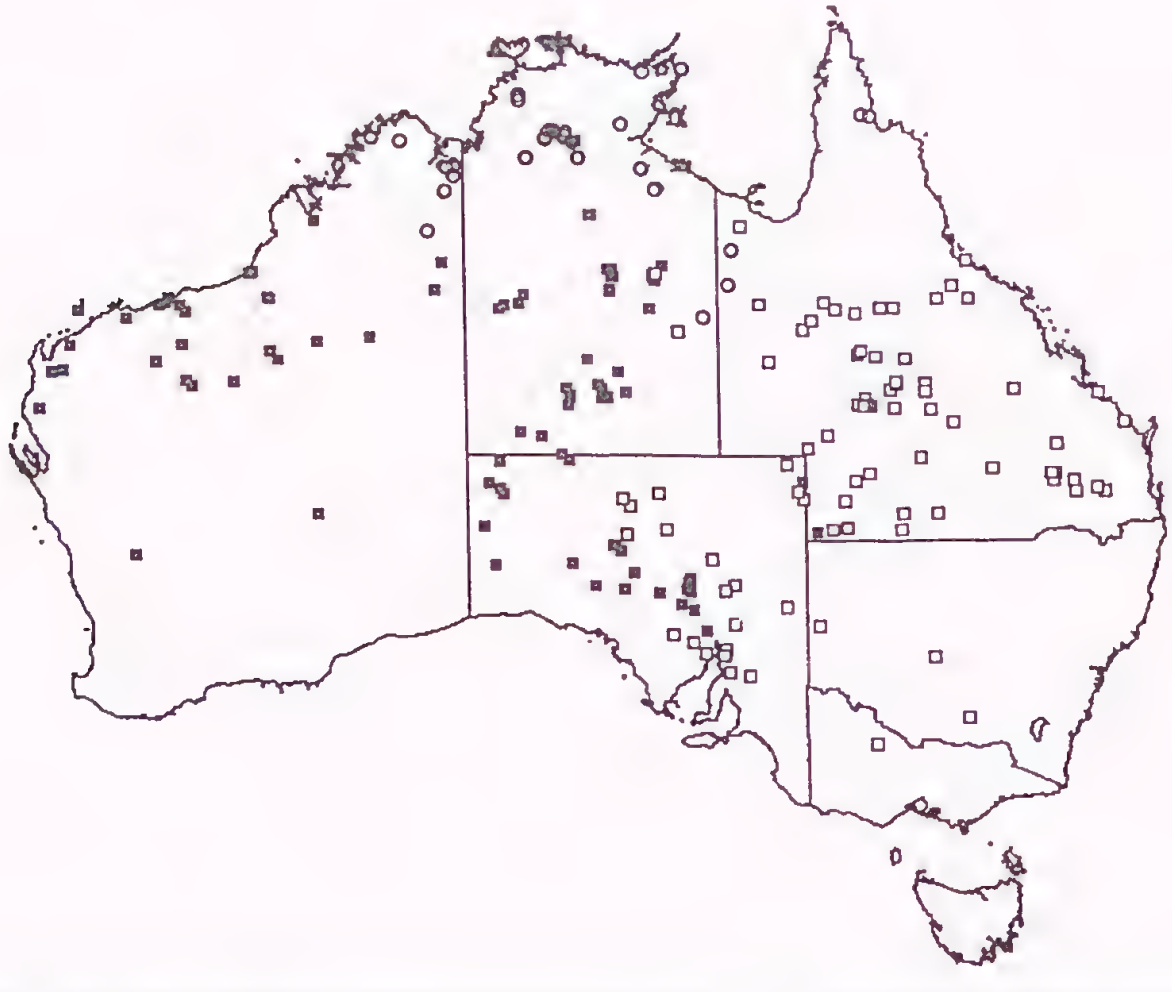

FIGURE 3. Map showing geographic distribution of specimens of *Pygopus* examined for morphological characters. ■ = *P. nigriceps*, ○ = *P. steelescotti*, □ = *P. schraderi*.

The *P. nigriceps* species complex conforms to Kluge's (1976) definition of the genus *Pygopus*. The dorsal surface of the head is covered with large and small scales, there are between three and five postmental scales, 21 or more midbody scale rows, nine or more preanal pores and the dorsal body scales are often keeled. The three species of the complex differ from the only other species in the genus, *P. lepidopodus*, in that the *P. nigriceps* complex has immaculate ventral surfaces (versus boldly variegated with black), smooth to moderately keeled dorsal scales (versus strongly keeled) and there is no dorsal snout pattern.

Pygopus nigriceps (Fischer, 1882)

Cryptodelma nigriceps Fischer, J. G. (1882), p. 290. Holotype SMNS 2259, Nickol Bay, WA. Type lost, believed destroyed during World War II (Schlüter and Hallermann 1997).

Delma (Cryptodelma) baileyi Günther, A. (1897), p. 170. Holotype BMNH specimen, now lost (Kluge 1974), from the neighbourhood of Cue, WA.

Pygopus territorianus Wells, R. W. and Wellington, C. R. (1985), p. 16. Holotype AMS R56823, near Tennant Creek, NT.

Notes

Both of the names that could be applied to the 'western' species are based on type specimens that are now lost. Fortunately, both have fairly precise type localities, which place them well outside the known distribution of the other two species. *Cryptodelma nigriceps* was described and figured by Fischer (1882) who proposed the new genus for this species, which appeared to combine the smooth scalation of *Delma* with preanal pores as in *Pygopus*. Fischer acknowledged that his very small specimen (SVL 64 mm) was almost certainly a juvenile, and its SVL is smaller than any we measured, although we did not extensively sample juveniles. The illustrations clearly depict the V-shaped preanal pore row (11 pores), large hindlimb flaps and head scalation (form of the two frontal shields and double row of loreal scales), a combination of features confined to *Pygopus* (*sensu* Kluge 1974). The dark head and nape markings are described and figured as confluent, unusual in specimens of the 'western' species but not unknown (e.g. SAMA R22932 from Barradale, WA).

Günther (1897) described his new species, *Delma (Cryptodelma) baileyi*, from an immature specimen (SVL 90 mm), noting that it was very close to Fischer's *nigriceps* but differed in its lower midbody scale count (22, versus 26 or 28). Fischer, however, implicitly included the ventrals in his midbody count, making his specimen's likely dorsal count 24 or 26, 24 being a frequent count in WA specimens. As with *C. nigriceps*, Günther's specimen had smooth scales and 11 preanal pores, both characteristic features of the 'western' group. Günther's illustration shows distinct black interorbital and nuchal colouring, with blackish narial and orbital patches extending on to the lower labials again features typical of the 'western' species.

Wells and Wellington (1985) proposed *Pygopus territorianus* as a new species from the Northern Territory, but provided little justification. They stated that this species could be 'readily diagnosed by consulting existing descriptive references' and the figure of a typical specimen (possibly the holotype) in Swanson (1976; Pl 34). They also added that the species lacks the distinctive keeling of the body scales seen in *Pygopus klugei* (*q.v.* = *P. schraderi*) and lacks the colour pattern ('reticulated patterning') of *P. schraderi*. The holotype is a specimen of the western form, and we therefore regard *P. territorianus* as a junior synonym of *C. nigriceps*. The body scales are completely smooth, the nostril is separated from the first upper labial and there are 11 preanal pores. The ventral count is relatively low (120) for the western form, but still within the sample range, and the colour pattern is markedly 'faded', with little black pigment remaining on top of the head, a trend in some populations of all of the *P. nigriceps* complex. The tail shows the strong pattern of dark-edged scales typically present in the 'western' form.

Neotype

To stabilise the name, a neotype, WAM R102063, has been selected for *Cryptodelma nigriceps*, from the same geographical area as the lost type (see notes). It was collected on the Yule River, WA (20°40'S, 118°21'E) by D. Robinson in 1990.

Diagnosis

A large pygopod (SVL up to 227 mm.) differing from other *Pygopus* in having smooth dorsal scales, the nostril entirely contained within the nasal, usually 120 or more ventral scales, and fewer than 14 preanal pores.

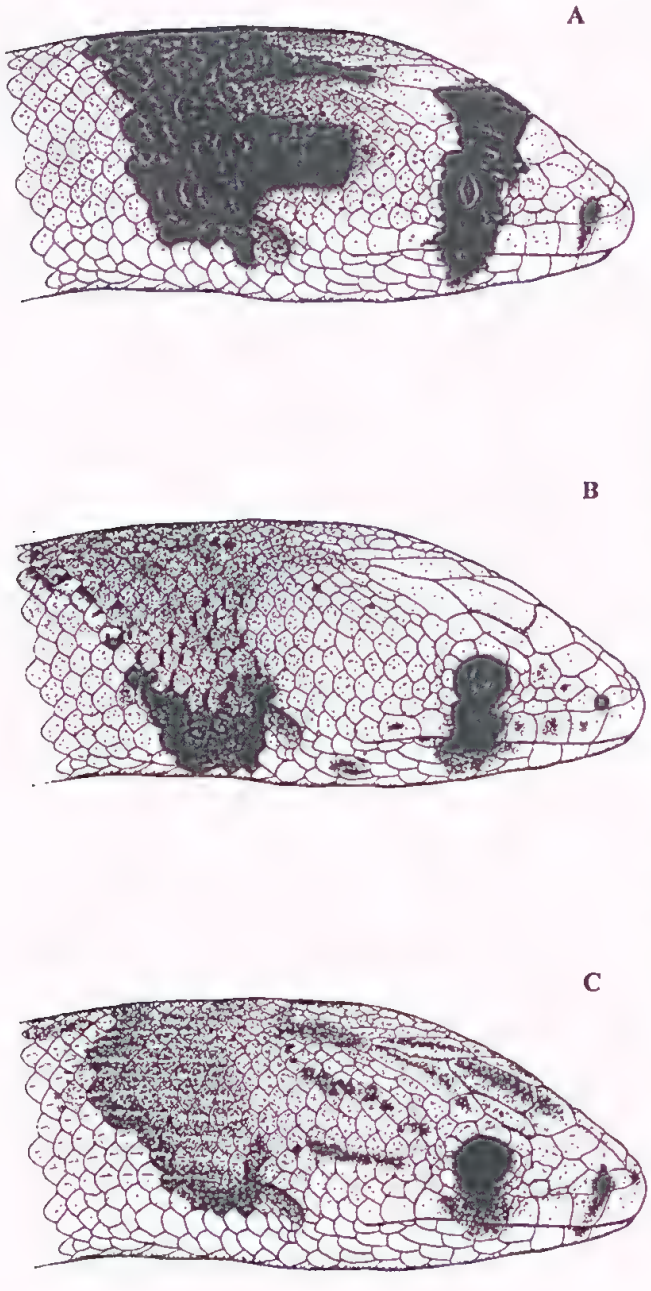

FIGURE 4. Representative head patterns of three species of *Pygopus*: (A) *P. nigriceps* (SAMA R48749); (B) *P. steelescotti* (NTM R20546); (C) *P. schraderi* (SAMA R46370).

Description

Ventral scales 114–143 ($\bar{x}$ = 130.0, S = 5.9, n = 116); orbital scales 9–16 ($\bar{x}$ = 11.6, S = 1.4, n = 118); nostril always completely enclosed by the nasal, separated from first supralabial scale (n = 119); preanal pores 8–14 ($\bar{x}$ = 10.8, S = 1.1, n = 117); snout-vent length 73–227 mm ($\bar{x}$ = 157.6, S = 33.7, n = 118); tail length ranges from 104% of SVL in smallest juveniles to 165% of SVL in largest specimens; no dorsal scale keeling (n = 118).

Colouration

In preservative, the basic head, body and tail colour is light tan to reddish brown. Scales, except for ventral scales, are speckled with brown or black pigmentation. Head, body and tail patterns are caused by the relative intensities and widths of the pigmented scale margins or by individual paler and darker speckled scales. Head patterns are formed with brown to black pigmentation and body and tail patterns by light to dark brown pigmentation. Ventral surfaces are immaculate with the scales a creamy-white or silver colour. There is a dark brown or black pigmented bar present on the dorsal surface of the head between the orbits which extends as a teardrop-shaped orbital patch descending to the supralabial scales and sometimes to the infralabial scales (Fig. 4A). A further area of dark pigmentation, but less intense, is found around the nostrils, again extending to the supralabial scales and sometimes to the infralabial scales. A brown to black nuchal band extends to the ear openings. There is no distinct body patterning. The tail is marked, often strongly, in the form of dark brown backward pointing chevrons that converge on the vertebral line. The smallest juveniles (SVL about 75 mm) are sandy-yellow with low levels of scale pigmentation except for the heavily black pigmented and contrasting head pattern. There is no distinct body pattern in juveniles and only weak light-brown chevrons on the tail. Coloration in life is shown in photographs in Storr *et al.* (1990: Pl 20, Figs 3–4), Glasby *et al.* (1993: Pl 4, Fig. 12), Cogger (1996: p. 297).

Distribution

West of 136°E and the far south-western corner of Queensland (Qld) (Fig. 3).

Pygopus schraderi Boulenger, 1913

Pygopus schraderi Boulenger, G. A. (1913), p. 564. Holotype BMNH 1946.8.27.2 (formerly 1913.7.28.2), collected at Milparinha [*sic* = Milparinka], NSW by P. Schrader.

Pygopus klugei Wells, R. W. and Wellington, C. R. (1985), p. 16. Holotype AMS field series 28686 (now registered as AMS R116980), 6.2 km S of Big Warrambool, NSW.

Notes

The holotype specimen is in good condition, with the colour pattern still readily discernible. It has an equal development of the orbital and narial

patches, but the interorbital area is only weakly pigmented. Although very young (SVL 65 mm), it has distinct low keels on the dorsal scales. There are 14 preanal pores. Boulenger (1913) gave the ventral count as only 97 pairs (enlarged scales only); the ventral count using our (Kluge's) method is 109. The characteristics of the type are completely concordant with the 'eastern' species in the complex.

Wells and Wellington's (1985) *Pygopus klugei* is a junior synonym of *P. schraderi*. The holotype specimen has 12 dorsal scale rows with distinct keels, there are 102 ventrals and the nostril contacts the first supralabial. There is a complex colour pattern on head body and tail, including well developed eye and nostril patches. Wells and Wellington were clearly influenced by the purported lack of keeling of the holotype of *P. schraderi*, a persistent misapprehension due to the rudimentary keeling in juveniles, including the holotype. Two illustrations said by Wells and Wellington to be *P. schraderi* (Cogger 1983; plates 104 and 495) show, respectively, a juvenile *P. nigriceps* and an adult *P. schraderi*.

Diagnosis

A large pygopod (SVL up to 198 mm) having unicarinate dorsal scale keeling extending over 10 or more rows, dark teardrop-shaped patches under both the orbits and nostrils, fewer than 120 ventrals, usually 13 or more preanal pores, nostril always in contact with the first supralabial scale and often strongly marked body and tail patterning.

Description

Ventral scales 100–122 ($\bar{x}$ = 109.4, S = 4.9, n = 85); orbital scales 6–13 ($\bar{x}$ = 9.87, S = 1.27, n = 85); nostril always in contact with first supralabial scale (n = 92); preanal pores 11–17 ($\bar{x}$ = 13.8, S = 1.4, n = 85); snout-vent length 70–198 mm ($\bar{x}$ = 142.6, S = 29.4, n = 91); tail length ranges from 99% of SVL for smallest juveniles to 170% of SVL for the largest specimens; dorsal scale rows with either weak or moderate keeling, usually moderate (80%), ($\bar{x}$ = 1.88, S = 0.28, n = 86) extending over 9–14 dorsal rows ($\bar{x}$ = 11.7, S = 1.8, n = 86).

Colouration

In preservative, the scales are pigmented in a manner similar to *P. nigriceps*. The background colour of the head, body and tail can vary from light tan to dark grey. The head is usually of mottled appearance. Head patterning is similar to that of *P. nigriceps* except that there is no pigmented band on the dorsal surface of the head between the orbits, the relative intensities of the pigmented bands below the orbits and nostrils are approximately equal and the nuchal band is frequently indistinct (Fig. 4B). Often, there is a strongly marked body pattern in the form of a longitudinal series of light or dark brown uniformly pigmented scales on the dorsal surface and upper flanks giving the impression of discrete broken lines. Many individuals have an almost continuous stripe along the vertebral line. On the lower flanks is a similar series of discrete broken lines caused by a scattering of creamy-white scales. The tail patterning is in the form of narrow crossbands (occasionally posteriorly pointing chevrons converging on the vertebral line). The body patterning is caused by individual scales of differing levels of pigmentation whilst the tail patterning is caused by scale margin pigmentation. The intensity of patterning is very variable with many specimens being strongly marked, others having a light tan overall colour and a washed-out appearance, whilst still others are heavily pigmented all over. Body patterning does not appear to be geographically correlated. The smallest juveniles are similar in size and colouration to those of *P. nigriceps*. Head patterns are pronounced and are brown or black. There is no distinct body pattern and only weak light brown crossbands or chevrons on the tail. There is weak dorsal scale keeling.

Colouration in life is shown in photographs in Wilson and Knowles (1988: Fig. 263), Swan (1990: p. 47), Ehmann (1992: p. 102).

Distribution

East of 135°E, south of 17°S and west of the Great Dividing Range in New South Wales and Victoria (Fig. 3).

Pygopus steelescotti sp. nov.

Holotype

NTM R20546, collected at Cape Crawford, NT (16°34.3'S, 135°57.9'E) by P. Horner, 1994.

Diagnosis

A large pygopod (SVL up to 185 mm) similar to *P. schraderi* except for weaker unicarinate dorsal scale keeling usually extending over less than 10 rows and a less complex color pattern,

with a dark orbital patch but no or very weak nasal patch.

Description

Ventral scales 103–125 ($\bar{x}$ = 114.2, S = 4.8, n = 43); orbital scales 7–13 ($\bar{x}$ = 9.86, S = 1.10, n = 43); nostril always in contact with first supralabial scale (n = 44); preanal pores 12–17 ($\bar{x}$ = 14.0, S = 1.0, n = 43); snout-vent length 79–185 mm ($\bar{x}$ = 139.0, S = 24.2, n = 43); tail length ranges from 100% of SVL for smallest juveniles to 152% of SVL for the largest specimens; dorsal scale rows keeling either absent or weak, usually weak (86%), ($\bar{x}$ = 0.86, S = 0.35, n = 44) extending over 0–13 dorsal rows ($\bar{x}$ = 7.1, S = 3.46, n = 44).

Colouration

In preservative, the background head, body and tail colour is light tan to sandy-yellow with patterns similar to those found on the less heavily patterned individuals of *P. schraderi*. There is often no pigmentation around and below the nostrils; if it is present it is usually faint in intensity compared to the teardrop below the orbits (Fig. 4C). Many specimens are light tan in colour and have a washed out appearance and, unlike *P. schraderi*, there are no strongly patterned or darkly coloured specimens. The smallest juveniles are similar to those of *P. schraderi* differing only in the head pattern and in having no (or extremely weak) dorsal scale keeling. Colouration in life is shown in photographs in Wilson and Knowles (1988: Fig. 264) and Ehmann (1992: p. 101).

Etymology

The species is named in honour of the late Dr Colin Steele-Scott, a keen supporter of the South Australian Museum.

Distribution

North of 22°S in NT, Qld and WA (Fig. 3).

Discussion

When considered as a single species, the concept of *P. nigriceps* that existed prior to this study was of an extremely successful, ecologically generalised arid zone lizard, adapted to a broad habitat range. The three species that we now recognise are each more restricted ecologically, as well as geographically. *Pygopus nigriceps* (*s.s.*) is primarily a sandy desert species, at least in Central Australia. *Pygopus schraderi* occupies a range of habitats, and while it has been recorded from sandy terrain (e.g. far eastern S.A.) it is typically found on rocky hillsides or clayey or stony flats. *Pygopus steelescotti* is less well-known with respect to habitat selection but differs again in being confined to the wet-dry tropical belt across northern Australia.

All three species in the complex may be strictly nocturnal, relatively unusual in pygopods, most of which engage in significant diurnal activity (Shea 1993). Field experience with both *P. nigriceps* and *P. schraderi* in South Australia indicates that specimens are only seen actively foraging at night, and pitfall trapped individuals are taken only overnight, not by day (M. Hutchinson pers. obs.).

Of the three species, *P. nigriceps* is the most easily identified, based on its completely smooth dorsal scalation, the nostril completely contained by the nasal, and the high ventral and low preanal pore counts. By contrast, the other two species are very similar, exacerbated by the tendency of geographically proximate populations of *P. schraderi* to be the most weakly patterned and therefore most similar to *P. steelescotti*. The similarity of *P. schraderi* and *P. steelescotti* is such that specimens from the potential area of contact along the southern margin of the wet-dry tropics in the NT and Qld should be carefully checked. At present, *P. steelescotti* seems consistently identifiable by the lower number of keeled dorsal scale rows (usually nine or fewer), weakly developed keeling on dorsal scale rows and differential development of the dark nasal (absent or weak) and orbital (moderately well developed) patches.

Further taxonomic work will be useful to help in defining the variation and degree of sympatry of the three dark-headed species of *Pygopus*. Taxonomic work is also further warranted on the northeastern Qld populations of *P. lepidopodus*. Based on our samples, the Cooktown specimen appears to be completely distinct from the more southerly populations, which themselves show some heterogeneity in morphology and electrophoretic markers. The status of the eastern Australian *P. l. squamiceps* Gray is yet to be properly assessed.

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Appendix

Museum registration numbers for *Pygopus* specimens examined. The superscript * denotes specimens which were used in the electrophoretic study. The superscript # denotes specimens used in the electrophoretic study where the body was not available for morphological analysis. Abbreviations in bold upper case refer to OTUs designated in the allozyme electrophoresis analysis. Institutional acronyms (underlined) follow Leviton *et al.* (1985) and ABTC = Australian Biological Tissue Collection, South Australian Museum.

Pygopus nigriceps: AMS R60245–6. NTM CAMR531, NTM R30, R157–8, R291–3, R321, R444, R829, R905, R1427–8, R1630, R2209, R2216, R2356, R2532, R3228, R3316, R5314, R5907, R6387, R7092, R9530, R9691–6, R9701, R9703, R9808, R14021, R15153*(**TAN**—30 km SW Sangster's Bore, Tanami Desert, NT), R17571, R18058, R18079, R20670*(**FIN**—Finke Gorge National Park, NT). QM J28440, J33389. SAMA ABTC6588*#(**MAB**—Mabel Creek Station, SA), ABTC31799*#(**MAC**—MacDonnell Ranges, NT), ABTC31812*#(**MAC**), R600, R876, R4791, R8116, R12911, R15548, R16279, R16768, R17459, R19251, R20711*(**OLY**—Olympic Dam, SA), R21029/33*(**OLY**), R21035, R22932–3*(**BAR**—8 km S Barradale, WA), R23197*(**LAV**—134 km ENE Laverton, WA), R23908*(**LAV**), R26198–200*(**MAB**), R26202*(**MAB**), R26222*(**MAB**), R26385, R26646, R26686*(**MAB**), R28546*(**BOO**—near Boologooroo Homestead, WA), R33824, R34003*(**NIN**—Ninghan Homestead, WA), R36152*(**YUL**—Yulara, NT), R36169*(**YUL**), R37139, R38785–6*(**TCK**—Tennant Ck, NT), R38824*(**TCK**), R38841*(**GLE**—near Glen Helen, NT), R42026*(**ILL**—21 km WSW Illintjitja, SA), R45264, R48608, R48668, R48749, R48765, R48792, R48830, R48928, R49156, R49310. WAM R5328, R5329, R13350, R19239, R26071–2, R30930, R36327, R40238, R52727, R64002, R64704, R69525, R73631, R73842, R75119, R75143, R79010–1, R81513, R82599, R83574, R94761, R95028, R94957*(**CAN**—Canning Stock Route, WA), R95670, R102055, R102061, R102063*(**YLE**—Yule River, WA), R103677.

Pygopus schraderi: AMS R6691, R8974–5, R26083, R65966. NTM R31, R8526. QM J11029, J1266, J2917, J2918, J5092, J5238, J7282, J7288, J7473, J7489, J7919, J8008, J8436, J8882, J9116, J9241, J13010, J13028, J13560, J21444, J21965, J22714, J23319, J23677, J24988, J25386, J33390, J33391, J33392, J33393, J33394, J33395, J35362, J37060, J40323, J40701, J40717, J44420, J44711, J44942, J46952, J48459, J51198, J51527, J51717, J52546, J52547, J52778, J52863, J54617, J54618, J54900, J55109, J57197, J57228, J58079, J5921, J59359, J59931, J61825. SAMA R2234, R4996, R5051, R5386, R5397, R5626, R5893, R9860, R11752, R16712, R23120*(**RM1**—Mt Remarkable National Park, SA), R23269*(**RM1**), R28389*(**IRO**—25 km NW Iron Knob, SA), R28927, R30403*(**COO**—25 km NNW Coober Pedy, SA), R40948*(**MID**—Middleback Homestead, SA), R42131, R42750*(**WIN**—15 km S Winton, Qld), R42947*/63*(**WID**—85 km W Windorah, Qld), R44808*(**COR**—Cordillo Downs, SA), R46247*(**ARC**—17 km NNE Arckaringa, SA), R46370*(**CAL**—Callana Station, SA), R46786, R48303, R49061, R49087. BMNH 1946.8.27–2.

Pygopus steelescotti: AMS R13233, R17981, R26579, R80336, R133267. NTM R99, R370, R821, R828, R830, R2270, R2271, R3790, R4730, R5033, R5280, R5303, R6423, R6677, R6704, R6777, R11247, R12416, R20513*(**CAP**—Cape Crawford, NT), R20545*–6*(**CAP**), R20588, R22333. QM J39061, J52746. SAMA R3510, R8117. WAM R23792, R56304, R70079, R70085, R70339, R75537–8, R83195, R83575, R87307, R99201, R101361.

P. lepidopodus: QM J47145*(**CTN**—Shipton's Flat, Qld). SAMA R33291*(**SYD**—Terry Hills, NSW), R20865*(**STO**—Stony Point, SA), R23629*(**RM2**—Mt Remarkable National Park, SA), R25341*(**HAM**—Hambidge Conservation Park, SA), R25689*(**YAL**—Yalata, SA), R30270*(**ESP**—Esperance, WA). WAM R77939*(**WAL**—Walpole-Nornalup National Park, WA), R90119*(**KAR**—Karridale, WA).

OBITUARY

PATRICIA MARIETJE THOMAS BSc, MSc, AO

13 April 1915 – 16 December 1999

Pat Thomas at Coolgubbin Camp, Connie Sue Hwy, Great Victoria Desert, June 1974.

Patricia Marietje Thomas, Pat to her many friends, died peacefully in Adelaide on 16 December, 1999, bringing to an end an outstanding career in parasitology. The elder of two daughters, Pat was born in Melbourne a year after her famous father, Sir Douglas Mawson, returned from the Antarctic but while he was in America. Pat was raised and educated in Adelaide, receiving her Batchelor of Science degree from the University of Adelaide in 1936, and her Masters degree two years later. She found employment in the Zoology Department as a part-time teacher in practical classes and researcher under Professor T. Harvey Johnston. After marrying marine biologist Ifor Thomas in 1947, and bearing three sons, Pat returned to academic life in 1950, spending most of it, apart from a short period overseas, in the Zoology Department until her retirement in 1980.

From 1981 until failing health slowed her down in 1995, Pat transferred her activities to the South Australian Museum, where, as an Honorary Curator, she greatly enlarged the helminth collection to a position of pre-eminence in Australia, and successfully pressed for its recognition as the Australian Helminthological Collection. With this achievement, Pat then worked to find a successor to herself, to continue the work, and in 1994 Dr Sylvie Pichelin was appointed as the first Curator of Helminths. Ian Beveridge, a younger colleague of Pat's, has listed her many professional achievements in Obituaries, Royal Society of South Australia (2000).

Pat was a worker, a helper, quick-witted and sharp as a tack, could show kindness and sensitivity when needed, and abhorred irresponsibility. In the following, a little about her personal life has been compiled after talking to some of her friends.

Philippa Horton (Collection Manager, Birds, South Australian Museum). 'I first met Pat Thomas at Adelaide University in 1974 during Zoology 1 practical classes for which Pat was a demonstrator. As a shy student I was in awe of her wealth of experience and knowledge, and was somewhat terrified of her forthright and no-nonsense manner. During one particular class—the dissection of a rat—a fellow student and I were having trouble in locating an anatomical feature. On being called for help, Pat blustered over, tackled our rat with forceps and scalpel, and severed one of its arteries. The body cavity filled with blood, obliterating anything we might have seen, and rendering the three of us helpless with laughter. From then on any feelings of terror vanished and were replaced with warm affection. One other occasion which stands out in my memory showed the warmth which was not always obvious in Pat's personality. I was pregnant with my first child and, at morning tea at the Museum, expressed the hope that it wasn't going to be twins. Pat described her own experience of giving birth to a son only THEN to find out there was another about to follow. She would have been thrilled with just one but was absolutely delighted to have two beautiful babies. She was filled with maternal love as she spoke and her words were a great comfort to a new mother-to-be. Nurturing twins must call upon extra reserves of physical stamina and strength of character: I was sure Pat had both in abundance.'

Mrs Anne Hardy, Rostrevor. 'I began to work as a technologist in the Zoology Department, University of Adelaide, for 25 shillings per week in 1940. Then the Mawsons were living temporarily in Ruthven Mansions in Pulteney Street. My job was caring for the fish, newts, snails etc. used in the study of parasitic flatworms and often at weekends Pat did it to save me coming in to feed them.

'When the Department moved to the newly constructed Benham Building which overlooked the river on one side and the Jubilee Oval on the other, Pat had the task of packing the huge collection of 'preserves' (specimens from the two 1929–31 British, Australian, New Zealand Antarctic Expeditions) a challenge which she excelled in.

'Once when the supply of dead rabbits for dissection turned up at the wrong time, it was necessary to skin them. Pat's technique was magnificent; a body held in one hand appeared to almost leap out of its fur. During the war, Pat took up marine biology and often accompanied groups to Port Willunga to study the reef. Her organising abilities were meticulous. As the war ended, undergraduate numbers ballooned out and the Professor deputed Pat and me, then a post-graduate student, to give repeat lectures. Pat had an engaging way with words.

'Occasionally Professor T. Harvey Johnston took us collecting near Tailem Bend and on one occasion, students were allowed to swim off a log in the river. One of the students got herself heavily entwined by the long strands of floating weed and submerged. When her panicky face surfaced, it was Pat who wrenched her out of danger. Typical of Pat, on having saved her life, she gave her a sharp rebuke for having done the wrong thing. One of my vivid memories was at the Spring School at the Marine Research establishment at Cronulla, NSW. Students at the school were housed a mile or more from the laboratories and used a bus to go to lectures unless there was a better offer, which in Pat's case, there soon was. As I waited for the bus, a motor bike with the school's tutor skilfully tackled the sandy track, and riding pillion was a passenger with bright red hair and skirts blowing and a face of blissful exhilaration as she clutched her future spouse Ifor Thomas.

'After her marriage, Pat had developed domestic enthusiasm. When I returned to teaching in the 60s and 70s in Zoology demonstration classes, she had won a shirt ironing contest at the Royal Adelaide Show, and with typical efficiency, produced three sons in fifteen months, sewed, organised and was soon back with her nematodes. I recall that names suggested for the twins were Son and MawSon. Later, Pat followed her mother as President of the Mothers and Babies Health Association.

'Pat and I took part in many of the ornithological excursions, led by Joan Paton, to the Simpson Desert, the Great Victoria Desert, Kakadu and many more. On one such, Pat complained about Rex Ellis's dog which took a dislike to her and protected the essential communal spade from Pat's urgent grasp.'

Mrs Anne Dow, Medindie. 'On an

ornithological excursion to Angorichina with Pat and Joan Paton, Pat overheard someone complaining about the food. Anne remembers Pat's quick response " I never complain about camp food, after all it goes in one end and out the other".

'Around the camp fire Pat had a delightful singing voice.'

Mrs Elizabeth Simpson, Stonyfell. 'The two Mawson girls and we three Cleland girls were great friends and spent much of our lives in the same pursuits. Pat and I were contemporaries at the University and many were the parties and excursions which we attended. I knew that if Pat was in attendance my enjoyment and performance would be heightened and all would be well.

'On many occasions in the bush after dinner I remember Pat with a Tilley lamp dissecting and searching for helminths. On one of Sir Douglas' geology excursions crossing a field, Pat and I noticed a cow giving birth to a calf. Although the cow was feeding placidly, the calf's head was protruding. Blushing hotly, for matters of that nature were a little taboo those days, Pat and I approached Sir Douglas and drew his attention to the phenomenon. Instead of leading the students in a different direction, he drew everyone's attention, in his loudest voice, to the plight of the cow. A minute later a calf was standing with wobbly legs alongside mother.

'Pat was a stimulating companion. She did not suffer fools gladly, even at times, her best friends. There were few of us who had not felt her critical tongue but this in no way detracted from the deep love and respect we held for her.'

Order of Australia Association, South Australian Branch Newsletter No 97; In Memoriam. Awarded AO, Queen's Birthday 1994, for service to the science of zoology in both research and teaching and the development of the Australian Helminthological Collection.

Slim Sommerville (retired zoologist, University of Adelaide) remembers how driving in the country with Pat was so appalling because she insisted on stopping to examine carcasses of dead animals. He also remembers being invited to dinner at the Mawson home in 1954. Sir Douglas sat tall at the head of the table and when kangaroo tail soup was served, he exclaimed 'What's this! I'll have none of it'. This surprised Slim knowing of the horrible food on which Sir Douglas had survived in Antarctica.

Dene Cordes (Department for the Environment), and **Noel Lothian** (formerly Director, Adelaide Botanic Gardens) were associated with Pat through the Board of the National Parks Commissioners and the Wildlife Advisory Council. There she was a particularly astute member whose lifelong interest in environmental matters enabled her to contribute greatly. She was interested in remote areas such as the Koonalda Caves which she urged should become a National Park, and this has since been achieved.

Sylvie Pichelin (Former Curator of Helminths, South Australian Museum). 'I first met Pat in 1995—the same day as the interview for the position of Curator of Helminths at the South Australian Museum. Both events made quite an impression on me. Although I had corresponded with Pat about the Collection, I did not know her personally. I knew of her impressive publication record but at the same time had heard tales of sherry in beakers next to kangaroo guts. I quickly learnt that Pat liked to call a spade a spade—a trait that was appreciated and helped me grasp the size and importance of the Helminth Collection. Pat was also very kind to me on my first visit and took me out to a delightful lunch. There are few like Pat—her death marks the closure of an era of parasitology in Australia.'

Cath Kemper (Curator of Mammals, South Australian Museum). 'Pat was always very interested in expanding the helminth collection so when I started to study (and dissect) cetaceans in the late 1980s she was keen for us to collect parasites and hand them on to her. Several times she came out to Bolivar herself and assisted with dissections. It was great to work with her because she always "hoed in" and nothing was too much trouble. I remember one day when she arrived at Bolivar before us and, not being able to get in and not wanting to do nothing, she set to work weeding the patio in front of the kitchen! It looked lovely and tidy when we arrived. I always had a great admiration for her because it would not have been easy to have been a female scientist earlier in her life. Science was something that men did and the few women involved were often considered odd. Pat was able to combine family and work so was just like everyone else, only much more determined than most!'

Archie McArthur (Honorary Research Associate, South Australian Museum). 'When I

started on the ant collection at the Museum it was Pat who "showed me the ropes"; she always found time to help me solve problems. She was often one of the first to start work in the mornings on the Invertebrate Floor of the Natural Science Building of the South Australian Museum, where as an Honorary Research Associate she built up the biggest collection of helminths from Australian animals. In addition to dissecting organs and extracting specimens, she spent months at a computer, cataloguing this vast collection. Occasionally, Joan Paton called in around noon and the three of us had lunch together in Pat's lab where she kept a plentiful supply of sweet vermouth. This she served in little beakers and even though we knew that the same beakers had contained a kangaroo's liver or a salmon's gut only minutes before, we appreciated her generosity and the purifying effects of alcohol.

'When her father Sir Douglas Mawson was teaching, Pat was often required as chaperone or cook on his many field trips. About one such expedition, Reg Sprigg reminisced in *Geology is Fun* (1989) "I relished an experience at the deserted Old Myrtle Springs Station ruins. We arrived out of Copley just before sunset. We carried little in the way of lamps so the race was on to beat the fading light. Patricia in commendably practical fashion grabbed a loaf of bread, placed it on the boards of a weather beaten and long abandoned old couch and got to work. Said Mawson "Whatever are you doing there Pat?" "Cutting the bread. Can't you see?" "But Pat, you can never tell what dirty old swagman has been sleeping on that. We could all get syphilis." Pat, never to be panicked, turned her head and nonchalantly answered, "You don't get syphilis through the mouth, Daddy." Father for once was stuck for words.'

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Archie McArthur, Honorary Research Associate, Terrestrial Invertebrate Section, South Australian Museum, North Terrace, Adelaide, South Australia 5000. *Records of the South Australian Museum* 34(1): 53–56.

CORRECTED IDENTIFICATIONS AND LECTOTYPE DESIGNATION FOR *POROCHILUS ARGENTEUS* (ZIETZ) (OSTEICHTHYES: SILURIFORMES: PLOTOSIDAE)

Australian plotosid catfishes are poorly understood (Merrick & Schmida 1984; Allen 1989) and, among other problems, the taxonomy of *Porochilus argenteus* (Zietz) is confused. The present note is intended to clarify the identification of the syntypes of *P. argenteus* and to designate a lectotype. Museum abbreviations follow Leviton *et al.* (1985).

Zietz's (1896b: 410, Plate 16, Fig. 7) description of *Plotosus* (= *Porochilus*) *argenteus* was based primarily on a single, 138 mm syntype from Cooper Creek near Innamincka, South Australia. Glover (1976) incorrectly listed this specimen (SAMA F1090) as the holotype. Zietz included other specimens but scarcely mentioned them. The specimen emphasized is clearly *P. argenteus* as recognized today by Allen (1989). Upon re-examination, it fits the description well, having a concave dorsal profile between snout and dorsal fin and a smooth inner face of the pectoral spine. Dorsal-fin ray counts were difficult to obtain as the fin is in poor condition; pectoral-fin ray counts were also difficult, although an approximate value of I-6 was obtained (*cf.* I-7 in Zietz [1896b]). It is the only plotosid listed from the Horn Expedition as 'type' in the original SAMA register. A second syntype, probably SAMA F1082 (Table 1), was discussed by Zietz (1896b: 411) as follows: 'A larger specimen of about eight inches total length, from Finke River, Hermannsburg, is of darkish colour; but this is most likely caused by having been dried formerly.' Additional syntypes are not specified, but localities were listed as Barcoo River, Finke River at Idracowra, and Palm and Ilpilla creeks, all in the Northern Territory. Extant syntypes are shown in Table 1.

Several lines of evidence identify all specimens except SAMA F1090 as *Neosilurus hyrtlii* Steindachner. Specimens of *Porochilus argenteus* are generally ligher coloured, whereas *N. hyrtlii* are usually dark. Zietz (1896a, b) did not record *N. hyrtlii* in other collections of the Horn Expedition, yet they are clearly present in the Finke River (Unmack in press). Specimens examined from the Horn Expedition (BMNH, NMV, SAMA) all are *N. hyrtlii* based on the following characters: convex or straight dorsal profile; rough inner side of pectoral spine; higher pectoral-fin ray counts. (Dorsal-fin ray and pectoral-fin ray counts could not be obtained from some specimens due to the poor condition of those fins.) (Table 1). All additional plotosid specimens examined (AMS, AMNH, BMNH, NTM, SAMA, NMV, WAM) from Finke River not associated with the Horn Expedition are *N. hyrtlii*. Finally, all SAMA *P. argenteus* syntypes (Table 1) were not registered until 1928 and, except for F1090, had been reidentified before cataloging as *N. hyrtlii*. Records of *P. argenteus* from the Finke River system (Zietz 1908; Glover & Sim 1978; Glover 1982; Allen 1989; Glover 1990; Larson & Martin 1990; Davis 1996; Kerle & Fleming 1996) are thus based on Zietz's record or on misidentifications of *N. hyrtlii*. The single specimen on which Zietz's (1896b) description was largely based (SAMA F1090) is hereby designated as the lectotype since it is the only specimen in the type series identified as that species; all remaining paralectotypes are reidentified as *N. hyrtlii*. *Porochilus argenteus* does not occur naturally in the Finke River system, where the only known plotosid is *N. hyrtlii* (Unmack in press).

Acknowledgments

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TABLE 1. Syntypes of *Porochilus argenteus* including present identification, number of specimens, size (SL = Standard length), dorsal (D) and pectoral (P) fin counts, locality and additional relative notes.

Catalogue no.	Species	No.	Size (SL)	D	P_1	Locality	Notes
SAMA F1082	*Neosilurus hyrtlii*	1 1	175 mm	I-5	I-9 (at least), right was I-10	Finke River, Central Australia, Hermannsburg	Specimen had dried out, collected by Kempe who was a missionary there. It was most likely collected prior to the Horn Expedition since the mission had closed for two years prior to the expedition (Gillbank & Maroske 1996), hence possibly explaining its dried state as originally noted by Zietz (1896b). Originally registered as *Neosilurus hyrtlii* Steindachner
SAMA F1088	*Neosilurus hyrtlii*	2	168 mm 192 mm			Finke River & Cooper Creek, Central Australia	Originally registered as *Neosilurus argenteus* Zietz (*hyrtlii*)
SAMA F1089	*Neosilurus hyrtlii*	2	101 mm 127 mm			Cooper Creek near Innamincka, Central Australia	Originally registered as *Neosilurus argenteus* Zietz (*hyrtlii*)
SAMA F1090	*Porochilus argenteus*	1	138 mm		I-6	Cooper Creek near Innamincka, Central Australia	Originally registered as *Neosilurus argenteus* Zietz
SAMA F1091	*Neosilurus hyrtlii*	3	114 mm			Idracowra, Finke River, Central Australia	Originally registered as *Neosilurus hyrtlii* Steindachner
"	"		110 mm		I-10	"	"
"	"		85 mm			"	"
NMV F8632	*Neosilurus hyrtlii*	1	82 mm	I-6		Finke Gorge	
BMNH 1897-1-20-46	*Neosilurus hyrtlii*	1	89 mm	I-5	I-10, I-11 (right)	Central Australia	

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A NEW SPECIES OF AUSTRALIAN *CANTHYDRUS* SHARP WITH A KEY TO THE AUSTRALIAN SPECIES OF NOTERIDAE (COLEOPTERA)

C. H. S. WATTS

WATTS, C. H. S. 2001. A new species of Australian *Canthydrus* Sharp with a key to the Australian species of Noteridae (Coleoptera). *Records of the South Australian Museum* 34(2): 61–64.

A new species of *Canthydrus*, *C. ephemeralis* sp. nov., from Northern Australia is described and figured. It is distinguished from the other known Australian *Canthydrus*, *C. bovillae* Blackburn, 1889, by size and dorsal colour pattern as well as a number of structural characters. A key to the genera and species of Australian Noteridae is included.

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Australia has a limited fauna of aquatic beetles of the family Noteridae consisting of only five described species in four genera; *Canthydrus* Sharp, 1882, *Hydrocanthus* Say, 1823, *Neohydrocoptus* Sato, 1972, and *Notomicrus* Sharp, 1882. All are essentially tropical although *Notomicrus tenellus* Clark, 1863 occurs in decreasing numbers down the east coast almost to the Victorian / South Australian border. Although all but *Neohydrocoptus* are extremely streamlined, they do not inhabit running water as their body form might suggest, but are found in still water in swamps, embayments and dams amongst emergent vegetation. All species are common, *Neohydrocoptus subfasciatus* Sharp, 1882, less so than the others. Most of the species fly readily to light.

In this paper I describe a distinctive new *Canthydrus* which is seasonally common in the escarpment country of coastal Northern Territory and adjacent Western Australia. All specimens are from the collection of the South Australian Museum.

Systematics

Key to the genera and species of Australian Noteridae (After Pederzani 1995)

1 — Fore tibia expanded beyond base of tarsi and with a strong hooked spur at the outer apical angle 2

— Fore tibia not expanded beyond base of tarsi, with several weak apical spines .. 5

2 — Prosternal process not broader than long, its apex about 2 to 2.5x as wide as its breadth between postcoxae; < 3 mm long *Canthydrus* 3

— Prosternal process broader than long, its apex very broad, at least 2.5 to 3x as wide as its breadth between postcoxae; > 4 mm long *Hydrocanthus* 4

3 — Elytron with a pale spot towards apex, as well as a medial one (Fig. 7), metatarsi stout (Fig. 3), metatibial spines of equal length (Fig. 3) .. *C. ephemeralis* sp. nov.

— Elytron without apical pale spot (Fig. 5), metatarsi more elongate (Fig. 1), metatibial spines unequal in length (Fig. 1) .... *C. bovillae* Blackburn

4 — Uniformly reddish; weak to moderately impressed row of punctures adjacent to the suture of the elytron .... *H. waterhousei* Blackburn

— Uniformly black; lacking sutural row of punctures ..... *H. australasiae* Wehncke

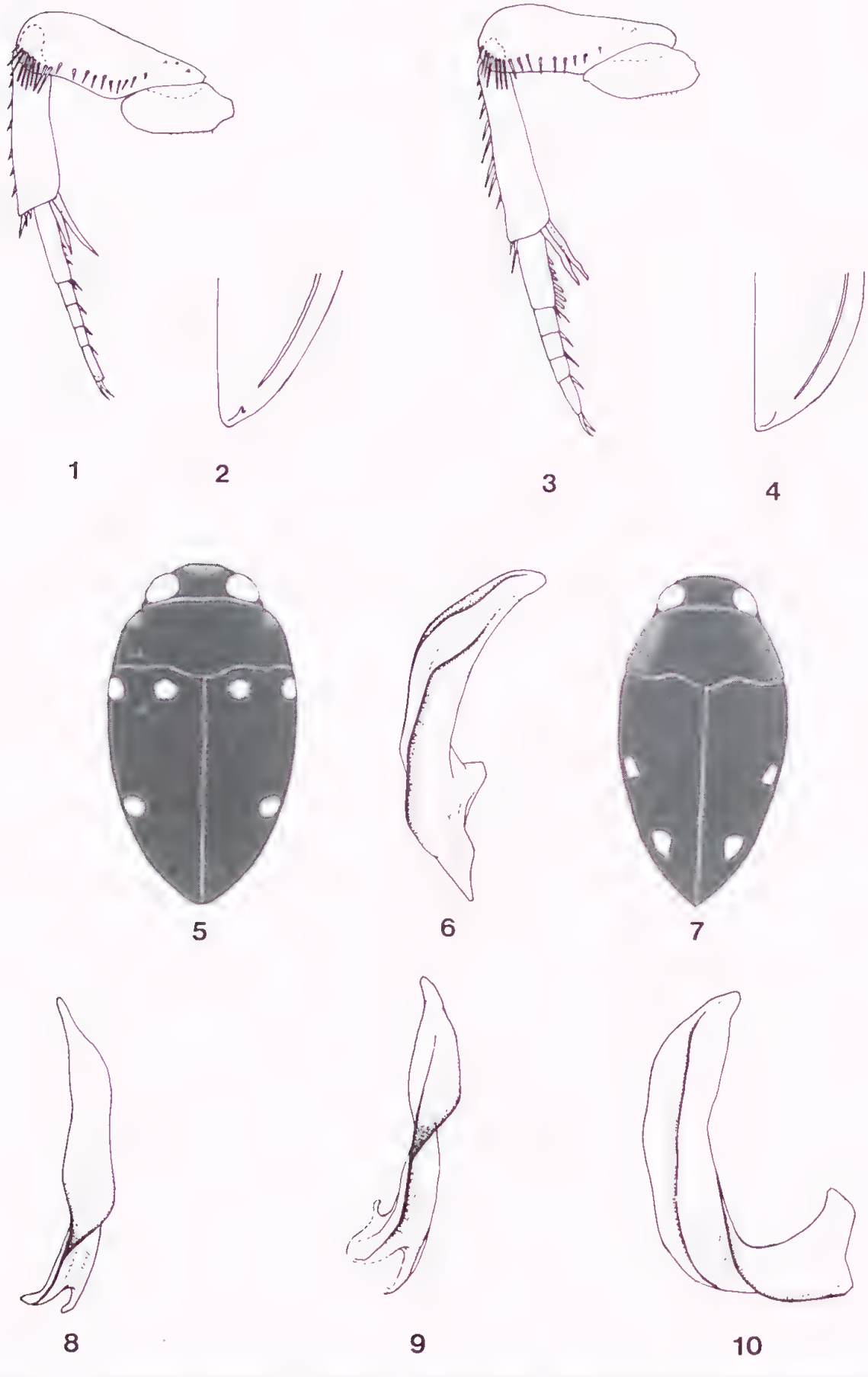
5 — Lateral margins of metasternal plate not bordered by a lateral ridge; < 2 mm long ..... *Notomicrus tenellus* Clark

— Lateral margins of metasternal plate with a lateral ridge; > 2 mm long..... ..... *Neohydrocoptus subfasciatus* Sharp

Canthydrus ephemeralis new species. (Figs 3, 4, 6, 7, 9)

Types

Holotype: male: 'NT 5 km SE Mt Borradaile stn. 8/10/98 C. Watts'.



FIGURES 1–10. *Canthydrus bovillae*; **1**, metaleg; **2**, tip of elytron (ventral view); **5**, habitas drawing; **8**, dorsal view of central lobe of aedeagus; **10**, lateral view of central lobe of aedeagus. *Canthydrus ephemeralis*; **3**, metaleg; **4**, tip of elytron (ventral view); **6**, lateral view of central lobe of aedeagus; **7**, habitas drawing; **9**, dorsal view of central lobe of aedeagus.

Paratypes: 29, 'NT 5 km SE Mt Borradaile stn. 27.5.99 C. Watts'; 14, 'NT Mt Borradaile stn. 26.5.99 C. Watts'; 33, 'NT 1 km W Gubara Kakadu NP 17.3.98 C. H. S. Watts'; 25, 'NT 5 km SE Mt Borradaile stn. 8/10/98 C. Watts'; 2, '6 km SE Mt Borradaile NT 8/10/98 C. Watts'; 5, 'NT 1 km W Gubara 17/3/98 C. H. S. Watts'; 3, 'NT 1 km W Gubara Kakadu NP 29/1/99 C. Watts'; 1, 'Darwin NT 13.5.63 CW'; 23, 'W. AUST. Ck on Phillips Range 16° 53'S, 125° 48'E 4 Oct 1982 B. V. Timms'; 4, 'W. AUST Dawn Ck 15° 57'S, 126° 51'E 5 Oct 1982 B. V. Timms'. All specimens in the collection of the South Australian Museum, except for 10 from 1 km west of Gubara which have been deposited in the Australian National Insect Collection, Canberra.

Description (number examined, 141)

Habitus. Length, 2.5–2.9 mm long. Elongate oval, deep bodied, moderately accumulate behind; shiny black, labrum and sides of pronotum testaceous, elytron with two yellow/white lateral spots, one in the middle, the other three-quarters the way to the apex (Fig. 7), appendages dark testaceous.

Dorsal surface. Smooth, virtually impunctate except for serial punctures which are traceable but weak, covered with fine reticulation, meshes small, regular, much smaller than eye facet. Head relatively broad, eyes large, antennae relatively short, segments 8 to 10 somewhat thicker, apical segment twice the length of penultimate. Pronotum with thin well-impressed line a little behind anterior margin, weaker towards sides, lateral margin with somewhat more strongly impressed line delineating a distinct beading. Elytron with well-marked lateral flange/beading.

Ventral surface. Smooth, virtually impunctate, covered with fine reticulation similar to dorsal surface. Apical segment of labial palpus large, oval, bifid at tip. Pronotal process wide, flat, strongly setose, lateral margins weakly beaded, approximately parallel-sided, narrower between procoxae, hind angles extended. Elytron epipleura very broad in anterior quarter, then rapidly narrowing, very narrow in apical half, absent near tip; apical ligula a smooth curve (Fig. 4). Raised midsection of meso- and metasterna broad, flat, widening towards rear, hind edge strongly concave, outer hind angle with three to four strong setae, covered with strong setae similar to those on pronotal process. Protibia with strong spine, approximately half length of tibia. Metaleg stout, apical spines on metatibia equal in length (Fig. 3). Hind margins of ventrites with row of setae, stronger laterally.

Male. External characters as for female. Central lobe of aedeagus with the apical 'overturn' which covers a broad medial groove less than half total length of lobe (Figs 6, 9).

Remarks

Canthydrus ephemeralis is most readily separated from *C. bovillae* Blackburn, 1889 by its smaller size (2.5–2.9 mm long against 2.9–3.4 mm) and dorsal colour pattern. *Canthydrus bovillae*, in general, is less strongly coloured with some specimens nearly completely black (identification from descriptions and specimens identified by Blackburn in the South Australian Museum). Well-coloured specimens (Fig. 5) differ from *C. ephemeralis* (Fig. 7) in having the front of the head testaceous rather than dark; the testaceous areas at the sides of the pronotum are restricted to the front, whereas in *C. ephemeralis* they extend along the whole side; two light-coloured areas at the base of the elytra (often indistinct) are lacking in *C. ephemeralis*; the absence of a subapical spot on the elytron which is present in *C. ephemeralis* (both species have a light coloured lateral spot in about the middle of the elytron). Other differences between the two species are: the shape of the ligula near the apex of the elytra—it has a pronounced indentation in *C. bovillae* (Fig. 2) which is lacking in *C. ephemeralis* (Fig. 4); the hind legs in *C. ephemeralis* (Fig. 3) are more robust than those of *C. bovillae* (Fig. 1); the metatibial spines in *C. ephemeralis* are of equal length (Fig. 3) whereas the inner one is longer in *C. bovillae* (Fig. 1); the meso-metasternal central plate is a bit broader in *C. bovillae*; the central lobe of the aedeagus has the medial groove covered for most of its length (Figs 8, 10) rather than about half as in *C. ephemeralis* (Figs 6, 9).

Distribution

Known only from the localities listed above under *Types*.

Habitat

All the collections of *C. ephemeralis* where the habitat details are known have been from small, temporary, wet-season, low gradient streams flowing off escarpments in the coastal Northern Territory and northern Western Australia. The substrate of these streams is clean sand or rock with accumulations of dead leaves and other debris in places. The adults forage in the open

sandy areas, at times in areas that may have water only after rain and are dry a few hours later. In contrast, *C. bovillae* lives in the more permanent flood-plain billabongs and is not found in the seasonal streams of the escarpment.

Etymology

In reference to its ephemeral appearance in streams that only flow during the wet season.

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TIMBU WARA FIGURES FROM PANGIA, PAPUA NEW GUINEA

PAMELA J. STEWART & ANDREW STRATHERN

STEWART, P. J. & STRATHERN, A. 2001. *Timbu Wara* figures from Pangia, Papua New Guinea. *Records of the South Australian Museum* 34(2): 65–77.

This paper discusses wickerwork figures known as *Timbu Wara*, formerly made in the Pangia area of the Southern Highlands Province of Papua New Guinea. The paper sets the historical context of the described figures. The figures were associated with a fertility cult periodically celebrated with large sacrifices of pigs. Wickerwork figures of this same general kind are known also from the neighbouring Kewa and Enga areas. After the cult was abandoned in the 1960s people began making the figures for sale to tourists.

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Introduction

The wickerwork ritual objects that we describe here were manufactured in the Pangia area of the Southern Highlands Province of Papua New Guinea (Fig. 1). The name Pangia was originally given to a single small locality south of Mount Ialibu in the Wiru language area. The Wiru language is related to a set of neighbouring languages in the Highlands which includes those of the Enga, Huli, Mendi and Kewa peoples (Wurm 1964). Among these languages, Wiru appears as a Family-level isolate, less closely related to the others than they are related among themselves (Wurm & Hattori 1982).

The first non-New Guinean outsiders to go through the wider area were the gold mining prospectors, Michael and Danny Leahy, during the 1930s. In the late 1950s government officers selected Pangia for their station after the first patrol outward from Ialibu. Catholic and Lutheran missionaries arrived shortly thereafter and set up stations at Yaraparoi and Tiripini in the close vicinity of the Pangia government station. Other missions followed—the Evangelical Bible Mission (at Mele) and the Wesleyans (at Takuru). Also, a linguist with the Summer Institute of Linguistics, Harland Kerr, came to live in the area at Poloko (Borona) where he studied the language and social practices of the people (Kerr 1975).

Relatively little has been published about the Pangia people. Jeffrey Clark, who worked in Takuru village, has written a number of articles about the impact of colonialism and Christianity on the people and his book *Steel to Stone*, which brings together and synthesizes the content of these articles, has been posthumously published (2000). (For further materials on the Wiru see Strathern & Stewart 1999a, 1999b, 2000; Stewart & Strathern 1999a, n.d.).

The Wiru are horticulturalists and pig-keepers and their staple crop is the sweet potato. The area has little primary forest and is mostly grassland and regrowth, dotted by limestone outcropping and sinkholes. This landscape has figured greatly in local notions of sorcery and spirit beings that were thought to live around settlements (Stewart & Strathern 1999b). In the past, long houses were built, through the initiative of male leaders, for important pig-kill ceremonies (Strathern & Stewart 1999a).

Pangia is encircled on three sides by mountain ranges. During the 1960s and much of the 1970s, travel into and out of the area was difficult. This remained so until the building of the Ialibu–Pangia road during the 1970s. Further, the Wiru traditionally had only minor trading and exchange links with non-Wiru peoples. Thus the impact of the colonial government and Christian missionaries was more extreme in a number of ways than in other regions where there had been more historical contact and interaction with other Papua New Guineans (Clark 2000; Strathern 1984; Stewart & Strathern n.d.). In particular, colonial control came to Pangia late, some 30 years after first contact in areas to the north such as Ialibu and Hagen, and the Administration attempted to bring about a swift set of social transformations and bring to the area the same 'developments' as were established elsewhere.

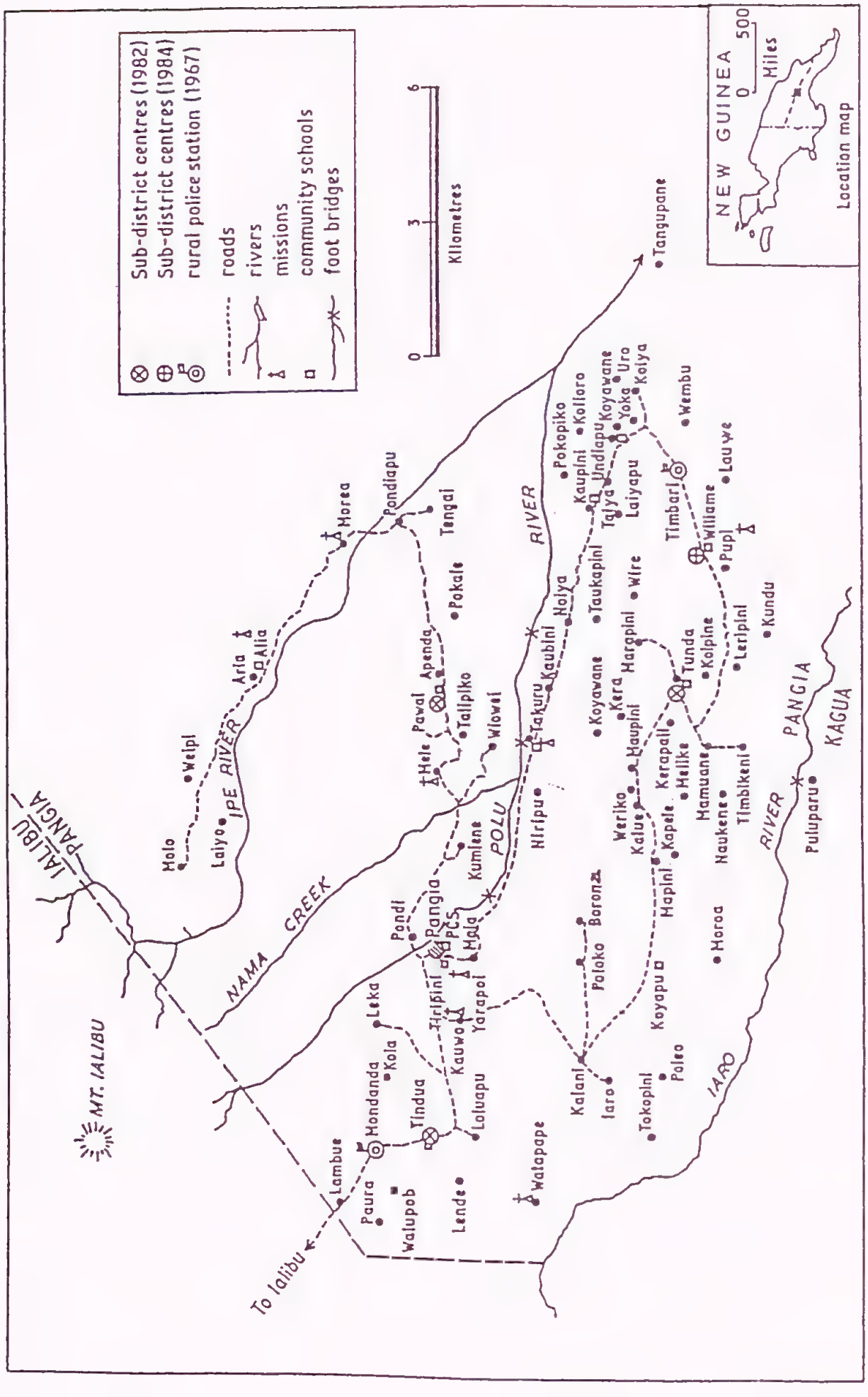

FIGURE 1. Map of the Pangia District, Southern Highlands Province, Papua New Guinea.

Prior to 1960, the Wiru had little experience in interacting with the colonial power. Non-New Guinean outsiders were said to have perhaps come from rivers (*uele nekenea*) because of their white color; hence their resemblance to spirit beings known to the Wiru people already. They were also referred to as 'red men' and 'spirits from the sky'. Non-New Guinean outsiders were seen as desirable and powerful entities since they were thought to have abundant wealth items. One way in which the Wiru adjusted to their presence was to make them feel, to some extent, as though they were insiders, thereby 'domesticating' them into the local transactional framework. They were identified as the wealth people, the people with possessions, as elsewhere in the Highlands also. This engendered a desire in the Wiru to obtain these possessions by whatever trading means were accessible to them. But the colonial powers had an agenda of 'development' that was not in harmony with the 'traditional' means of sociality familiar to the Wiru.

The colonial administration required people to work as labourers on road projects and government buildings and to seek permission to hold pig-kills which might disrupt road work schedules. There was a great push to bring Pangia up to the 'development' level of other, longer-contacted areas of the Highlands. Thus the Administration reduced the time that the people had to adjust to these outside pressures which had come into their lives. Since the missions had come into the area on the back of the colonial government, the Wiru in some ways conflated the two and their expectations of what would eventually be obtained by participating in 'development' projects and mission activities was very great indeed, escalating with every passing year.

Initially, the Administration regarded various 'traditional' practices as a hindrance to 'development' in the area and some of the missions labelled 'traditional' cult practices as satanic. This was particularly true of the Evangelical Bible Mission and the Wesleyans. The Wiru had accepted Christianity into their pantheon of cults as a powerful new practice that might assist them in obtaining the good health and wealth that they thought the non-New Guinean outsiders possessed. Christian missions did bring schools into the area, which many even today remember as a positive change. In 1999, a middle-aged Pangia man from Wiliame village told us that he had appreciative memories of the missionaries, saying that 'they brought schools, roads and teaching about hygiene' which he felt allowed him to have a better life and his children to become educated and earn money.

But some missionary workers, notably indigenous evangelists, also ordered the smashing of cult stones and the burning of cult houses—a practice also followed in other areas of the Southern Highlands such as among the Duna (Strathern & Stewart 1998; Stewart & Strathern 2000). Before the coming of the missions, the Wiru held pig-kills in association with a number of religious cults: *Timbu*, *Tapa* and *Aroa Ipono* (Strathern & Stewart 1999b; Stewart & Strathern 1999a). These cults all aimed at bringing health and fertility to the people and involved the construction of specific ritual objects and buildings. The *Tapa* cult centered on ancestral stones belonging to subgroups in each settlement area, and had to do with sacrifices of pigs made on occasions of sickness. The *Aroa Ipono* belonged to a widely spread complex of such cult forms, also found in the Western Highlands Province.

The *Timbu* Cult

The *Timbu* cult involved the construction of a specific cult house, which contained a central post (*tungi*) onto which were attached the shoulder and jaw bones of many pigs that had been killed over the years prior to the culmination of the festival. The cult's cycle of enactment was approximately five to eight years, ending with a great feast in which hundreds of pigs, the raising of which involved innumerable hours of female labor, would be killed. Prior to the pig-kill and ceremonial exchange marking the end of the cult cycle, the cult participants would dance around the *tungi* post holding the *timbu wara*. Subsequently, the *tungi* post would be taken out from the cult house to the ceremonial ground where the pig-kill and ceremonial exchanges took place. This would be in the area of a main village (*tumbea ta*) where cult houses of various kinds were located.

The *Timbu* cult was aimed at restoring ecological balance and fertility to humans, pigs and the land. The cult looked outward and brought together clans from other neighbouring districts, reinforcing continued exchange relations. It also may have functioned to redress exchange imbalances and outstanding debts that arose from warfare deaths (Dosedla 1984). The term *timbu* means 'sky', so the cult may have had a

connection also with mythical Sky Beings who are seen as important in other Highlands cosmologies. A comparable cult complex known as *Timp* is found in the Mendi area (Lederman 1986).

The cult involved various male age and status grades. Prior to the cult's culminating pig-kill, the participants would receive lengths of sugar cane that demarcated the quantity of pork they would subsequently receive. Although only males were allowed into the cult house, females participated in the production of the foodstuffs for the festival and the pigs for the feast. They also had the highly significant role of carrying back to their respective settlements the pork received at the ceremonial distribution.

Central to the whole process by which a *Timbu* performance was organised was the sacrifice of large numbers of pigs over a period of time, so as to provide bones to festoon the central pole. Informants agreed that marsupial bones would also be attached to the pole; some declared that the bones of rats and eels were also used. There were probably local variations in this regard. The overall purpose was clearly to show how many animals had been sacrificed to the spirit. When the pole was covered with bones, it was said that 'it is ripe' (*nondokako*), that is ready for the climactic phase of the cult. Men and boys were the ones who entered the tall house in which the 'bones pole' was kept. Older men were in an inner circle, with younger men at their back. A ritual specialist made spells for health and fertility, which were said to come up from his stomach, his *tepe*. For each cult house there was a single leader who held the knowledge of these spells and was therefore said to be the man in charge of the cult site (*yopikango*). Such a position of leadership and knowledge might be passed from father to son. But the knowledge could also be passed on between specific lines of descent within the larger residential complex of the settlement.

Joint participation in the cult was a mark of unity; separate performances later would mark social processes of differentiation over time. Two performances might be held in the same place, then a shift would occur. Clearly the *Timbu* represented the ongoing social life of a named group and its diachronic extension and alteration.

The exclusion of women and young children from the inner cult area does not mean that the *Timbu* was an exclusive 'men's cult'. The whole purpose of concealing the post and festooning it with bones was so it could be brought out later and displayed to the community at large, when the final dance for the 'coming out' of the pole was staged. One senior informant said that 'after this the young men could find wives for themselves'.

The parts of pigs that were taken inside the cult house for consumption were the tail-joints (regularly used in ritual contexts elsewhere in the Highlands, such as among the Duna of the Lake Kopiago area) and the sides. The inner parts, including the entrails, and the heads of the pigs were given to the women to eat. A woman would dance up to a 'fence' and hold up a pig to be killed. The men rushed at it calling out and clubbing it as it squealed. The women then stood at the fence and received their portions of the pig to cook. When the 'bones pole' was finally buried at the end of the performance, both men and women were said to have participated in this final ritual act.

The *Timbu* spirit was said to be male—*ali*, 'a man'. The bringing out of the pole was therefore like the bringing out of a male initiate from a condition of secrecy into one of display. Prior to this moment of display in the ritual process, women and children should not see the pole because if they did so, their legs, arms and vaginas would suffer from sores described as 'scabies'. That is, if they saw the *Timbu* when it was 'unripe', the result would be the opposite of the effect of showing the spirit to them when it was 'ripe', like a mature, healthy man.

The *Timbu* also presided over marsupials. If hunters failed to find marsupials in the forest they would attribute this to the spirit. Hence the point of hanging trophies on the pole as a sign of hunting success—these were both a return to the spirit for granting access to the game and a demonstration to the community of this access.

The spirit was said to dislike pigs' heads because pigs spoil people's gardens. If the *Timbu* saw pigs' heads it too would spoil gardens in the same way, it was declared. We see here a sign of the latent aggressiveness believed to be inherent in the spirit.

Other taboos were observed. The participants made small flutes and blew these to warn women and children not to look when cult paraphernalia were being carried into the house. The flutes were blown also when pork was cooked and divided out in the cult place, to prevent sickness in people and pigs. These flute sounds were said to imitate the calls of two marsupials known as *tekelepo* and *wapenge*, which came 'along with the *Timbu* cult itself', it was said. The marsupials' call of *tu-li, tu-li* inspired the flute-blowers to imitate them. The spirit's connection with the forest and its

game is reaffirmed in this detail, while the act of blowing the flutes links the cult to a wide spectrum of such practices in the Highlands region as a whole.

Finally, the cult's forest associations are shown in the practice of roofing the cult house with wild pandanus leaves and black palm thatch, into which pig bones were pushed. White and rusty brown forest leaves were used to decorate the house; these also appear as decorations on houses for spirit cults in the Hagen area north of Pangia. We are dealing here with the fluid transmission of cult elements from place to place, in which forest associations are a constant feature.

After the performance was over, the pole and all pig bones were carefully buried. At the burial site the participants planted a *kendo*, a cordyline shrub, as a long-lasting marker, surrounding the shrub with boards. (This would make them like the *pokla mbo* which marked *moka* events in the Hagen area.) It seems likely that the *kendo* marked the place where the spirit and its power was now located in a dormant mode. The actual dance for the culmination of the ritual activities also involved wearing tall cordyline sprigs as bustles at the back. Pairs of men danced facing each other with their bustles bouncing at their backs, singing songs to the *Timbu*. The dance was called *polo pendeko*, 'the bending dance'. Men cut a pandanus leaf and blew musical notes on it as they performed it.

The *timbu wara* wickerwork figures which are the focus of this paper were made to be worn on the heads of the male dancers who participated in the climactic phase of the cult. We quote here initially two statements in 1967 by senior knowledgeable male informants of two different settlement areas in the southern part of the Wiru speaking area:

> We make a figure of a man with rope and decorate it. When we kill the pigs we carry it on our heads. We put tall cordyline sprigs in our rear bustles and we carry bows and arrows. (Longai of Tunda village)
>
> We made a *wara*, like a man, and placed it on our heads. This was a good custom; it was our own. If this figure was not made, pigs, men, women, and children would all become sick. We killed a pig [as a sacrifice before constructing the figures] and we made a 'picture' [*yomini* in Wiru] of the spirit. One special kind of rope and one special liana were used to make the *wara* and we carried them on our heads at the time of cooking pigs. Women could not hold these *wara*, only men and their sons ...[After the performance was over] some *wara* were buried, but some were kept. Out of fifteen, maybe ten were buried but five were kept. For the next performance we made new ones and finally buried the remaining old ones. But now all the *wara* have been thrown away. The Lutheran Mission men cut up the *wara* with their axes. (Kuluwa of Marapini village)

Another old ritual expert noted:

> In the past we made gardens of taro, bananas, sweet potato, and they all grew big. Now that we have given up the *Timbu* our crops are small. In the past pigs and men were large because of the *Timbu*. Now they are small. (Wipai of Tunda village)

In spite of this tone of regret, shared by many others at the time, the *Timbu* cult had vanished from the Wiru area by 1967. In several instances it was reported that the *yopikango* of the cult had himself turned in its sacred stones to the missions or had declared that it would not be performed again. Since he was the authorized expert for the group, his decision could not be challenged. Such men were afraid of the messages of Hell and sin that the missions brought with them. When asked if the people could themselves have cut up the *wara* and destroyed them, informants unequivocally said 'No, we could not have done this, because we were sorry (*ela toka*) for the *wara*.'

In Tunda village in 1967, an effort was made to collect a number of these wickerwork figures used in the *Timbu*. Tunda village had a road into it, making access somewhat easier although the road was often barely passable to vehicles. The people were converted to the Lutheran and Catholic forms of Christianity, and the settlement itself was artificially structured through the actions of the government bringing previously separate small settlements together (Strathern 1984; Stewart & Strathern n.d.). Tunda was, however, a traditional *tumbea ta* or 'big place', functioning as a ritual and political centre for surrounding hamlets. Some villagers at this time still possessed the knowledge of how to make the wickerwork figures called *timbu wara*, even though the *Timbu* cult was no longer practised.

The Lutheran Mission in the area was very active, as was the Catholic mission. Tunda was divided between these two. Hageners from the Western Highlands were working with the Lutherans at this time, and these Hageners boasted that they were involved in removing the ritual cults of the local people. But the actual time period since the arrival of Christianity, and the changes associated with it, was short; thus,

the people still retained a great deal of knowledge about previous religious activities such as the *Timbu* cult, although they were sometimes reluctant to discuss these in any detail.

The *Timbu Wara* And Christian Missions

Timbu wara ('the spears of the *Timbu* spirit') were very striking wickerwork figures known from only a few areas of the Southern Highlands. As indicated above, these figures were made specifically for a particular cult performance and then buried or allowed naturally to decay. They would not have been kept indefinitely, so there were no heirloom examples that one could purchase for a museum collection. Even if some had been retained in the past, the missionaries had ordered the people to destroy or burn any remaining items from their pre-Christian religious practices. Therefore, a request had to be made to the people to manufacture some of these figures for a collection to be sent to the Museum of Archaeology and Anthropology at the University of Cambridge.

Several local youths agreed to make them for a set fee. They were sons of men who had the right to wear such items in the past and there was no bar to learning from their fathers how to make them. In the past, these items were not made by the ritual experts, whose power lay in their knowledge of spells for the cult.

When the completed figures were presented they were placed vertically on top of the heads of the craftsmen to show how they had been worn in their ritual context. They were shaped like a human figure but they represented the *Timbu* spirit. At the time of presenting the figures, their makers carried them in this displayed manner through the village, which was close by a government road. At the moment that this parade was occurring, a local fundamentalist missionary from the Evangelical Bible Mission at Mele was walking along the road from Mamuane village, where he wanted to set up a mission station. The missionary's baggage carriers pointed at the men with the *timbu wara* figures and began to yell out, 'Satan, Satan, Satan figures are coming!' They were told that these were not Satan figures but rather artifacts that were commissioned to be made for a collection and not for any religious purpose, but these men were very afraid and went off. The missionary himself was rather upset and also went off without any further discussion of the objects.

Ironically, this missionary later did subsequently set up a church in Mamuane village with the stated aim of bringing into congruence Christian ideology and aspects of indigenous culture. But in the course of doing this it was reported that he made a number of transactions in which the people felt they had not obtained enough in return for services rendered and they took revenge by burning the mission station down, forcing the missionary to leave.

The *timbu wara* figures were, as we have noted, objects made to celebrate the action of dancing for the *Timbu* spirit during the cult performance. The central ritual objects of the cult were items (which could include, for example, a tree fungus which was hard and stone-like and was called *timbu kapa*) that were kept in the specially constructed cult house, and pigs were sacrificed to these items. One of the senior men, who had himself been a custodian of the cult, explained further some of the ritual actions that were performed:

> Inside the house they dug a hole and they made *man* [magical spells] over it. They used a pearl shell to scoop out this hole, speaking a spell over it also. Inside the cult house they planted tree saplings. They killed pigs and filled blood from them into a bamboo tube. They also took tree oil and poured it along with the blood into the hole. They took a special leaf, *timbu yombolu*, and buried it in the hole with the oil and blood. For every action they made a special *man*, including the house-building. When we had killed the pigs we made a special net bag, *tetaleme ka*, like a woman's net bag, made from rope, which we carried outside. The axes we used to cut this rope in the bush and to cut the wood for the house were all bespelled in advance. We used four different sorts of wood for the actual pole on which we hung the pigs' bones and also the bones of eels and marsupials. These woods were *tungi*, *lepa*, *walea*, and *pokota*. (Kuluwa of Marapini village)

This quotation gives some idea of the complexity and diversity of the ritual acts performed inside the cult house. The action of giving tree oil to the ground also parallels the Hagen male spirit cult sequence in which *Campnosperma* oil is poured into the 'spirit's eye' (see Stewart & Strathern 2001: 99–112). The *wara* in a sense marked the successful performance of these other acts: the creation of the spirit as 'a man' (*ali*), representing the regeneration or revivification of the community itself. The fact

that *wara* figures, like the 'bones pole', were all buried does not mean that they were casually discarded. Burying items in the ground is a way of preserving and containing their force, as is abundantly testified from all over the Highlands. Since the pole was buried at a site where a *kendo* or cordyline was planted as a marker of group identity, we may reasonably suppose that the *wara*

FIGURE 2. These two boys are displaying decorations they have been involved in making to demonstrate the methods of manufacture of *timbu wara*. The boy on the left wears one figure attached to his head and holds another in his hand. The boy on the right wears an *alipo* wig with a set of bird plumes mounted on bamboo pieces above it as a headdress. The *alipo* wig style belongs especially to the Ialibu area north of Pangia. The house in the background is a newly made house for cooking food, beside a large dwelling house.

were buried in the same place. Elsewhere in the Highlands, ritual items were left to decay or were buried, for example the *gerua* boards or painted plaques found from the Wahgi area eastwards to the Siane (O'Hanlon 1989: 102ff.).

At this historical moment, in the 1960s, the fundamentalist Christians from one of the missions were saying that these *timbu wara* objects were 'satanic' and should be destroyed. But the Lutherans and Catholics of the village were not making this a particular issue. The Catholic priests of the Capuchin order in the area

FIGURE 3. A close-up of the *timbu wara* figures.

had even used these objects to decorate their own houses and encouraged people to make them as tourist objects so as to obtain some income. By suggesting the objects be used as tourist items they were also deflecting the people away from associating them with the ritual itself.

THE *TIMBU* FIGURES

Figures 2–4 show the designs of the two figures that were constructed for sale in 1967 in Tunda village. The two boys were those assigned to carry the objects and who had been involved in their

FIGURE 4. Rear view of the *timbu wara* figure attached to the bast lining of an *alipo* wig, along with feather decorations mounted on rattan.

making. Both figures were flat constructions with protrusions representing arms and legs; they were coloured with earth pigments. One also had a rudimentary head on which a headdress was mounted. This figure had a central strip of white running from its head to its genital area. It is likely that this strip marked the presence of vital 'grease', of fluid in the body. The second figure had a softwood plaque marked alternately in dark and light colours to resemble the pearl shell ornament hung on the body. It may be thought to have signified the idea of the body as wealth, a significant notion in Pangia. It may also have represented a notched hornbill beak, a favourite design also painted on men's noses at pig-kills (*kaila timini* is the name of this design); each of the *timbu wara* in the South Australian Museum (A.66227, -8) has a real hornbill beak attached as the head (Figure 5).

Comparative Materials

The *timbu wara* figures are one of a category of objects that are found also in other areas of New Guinea. Heinz Dosedla (1984) has written a review article on this category of woven figures that are made from flexible materials. He discusses items from the Southern Highlands Province, including the Enga, Kewa and Wiru peoples. His classification, based on a survey of the literature available to him, includes a set of figures that are in the shapes of animals, 100–180 cm in length and decorated with earth pigments; and a second set of anthropomorphic figures, 60–90 cm in height, unpainted, and with an enclosed cavity. For both types, a spiral weaving technique was used in their manufacture, in which plant materials were bent and wound around a supporting frame that was made from stiffer materials, such as bark rope in some instances.

Dosedla states that among the East Kewa of the Kagua District, who had trading relations with both the Enga and Wiru peoples, the woven figures were significant in the cult known as *Rimbu,* which ensured fertility through sacrifices to the dead. The cult included the use of flat woven figures whose construction had been supervised by special ritual experts. These figures resembled those that the Wiru used, but these Kewa figures were in the shape of animals and they were worn by dancers on their lower chests. The figures were said to represent spirits of dead

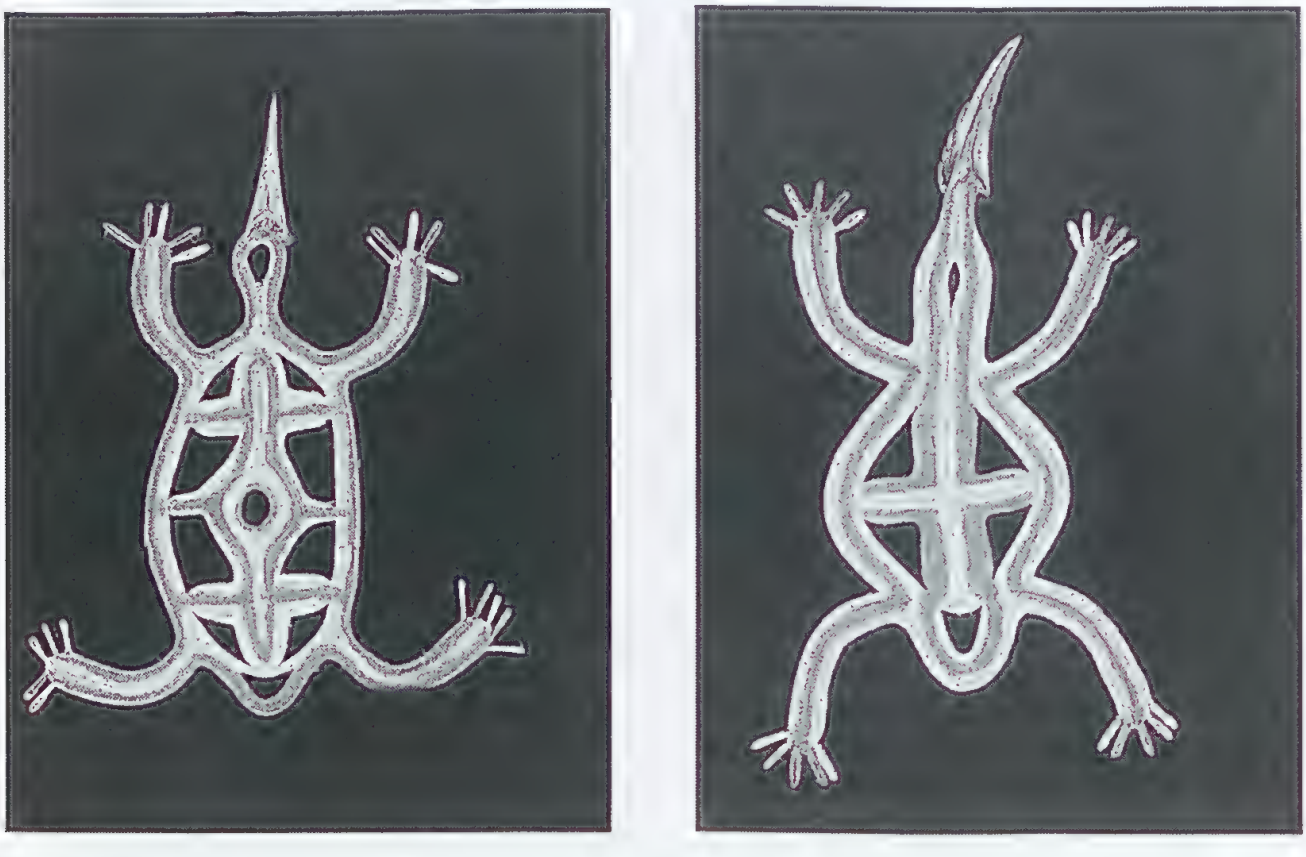

FIGURE 5. Two *Timbu wara* figures in the South Australian Museum (A.66227, -8), each with hornbill beak attached. Purchased from Stephen Kellner of Sydney in 1977. Kellner purchased from a private collector c.1972. Photo courtesy South Australian Museum.

members of the clan. The East Kewa *Rimbu* cult also employed the second category of woven figures—the hollow anthropomorphic ones—which were used as freestanding figures in conjunction with cult stones.

The *Rimbu* cult festival developed over a number of years with several stages of activity and involved two separate groups of men, the 'red' and the 'black' sections. These two colours are symbolically associated elsewhere in the Highlands with dualistic schemes of classification. The 'red' group took control of the anthropomorphic figures and the cult stones, while the 'black' group took control of the animal-shaped figures. The latter were displayed and carried at the end of the ritual by cult participants.

Dosedla also describes wickerwork figures from the Enga area. One type called *yupin* was kept in a special spirit house (*yainanda*, war house) along with cult stones. The *yupin* figure, seen as 'male' and marked by its prominent genitals, was thought to have intercourse with the rounded cult stones, bringing fertility to the land, pigs and humans. (See Wiessner & Tumu 1998: 199, 204, 207 for further details on Enga *yupin* or *yupini* figures.)

Neich (1976) provides a valuable survey of *yupin* figures derived from information provided by an Apostolic Church missionary, H. M. Reah, who lived in the Yandapu Enga area for some ten years in the 1960s and 1970s. Reah's account indicates that these figures were considered very powerful; that they were appealed to in times of drought; that their keepers would ritually place them on top of round flat female stones with holes in the centre; and that groups tended to have their own *yupin* figures. But several groups might come together on an inter-local basis to ask the *yupin* for health and prosperity in times of sickness.

Neich says that *yupin* figures had to be made from special vines (as was true for the *timbu wara* also); that their manufacture was commissioned and the maker rewarded handsomely with shells and axes; and that women and children were not allowed to see them. If a woman saw one, her next child would be born deformed. If a child saw one, he or she would fail to grow.

Here, the logic of time reversal was operating. Seen 'out of time', the *yupin* would harm, not help, the community. Most valuably, Neich provides information from a number of Enga areas, including those that are closer to the Kewa, on variant designs and names of *yupin*. One was from Margarima and was said to represent Tatagali-Wabe or Tali-eli, a major spirit appealed to when gardens did not grow well. It is interesting to note that this is the name Glasse gave to a supreme spirit among the Huli people (Glasse 1965). The name *yupin* itself may mean 'root or base man', that is 'the source of things'.

All *yupin* figures are cylindrical, with a hollow area inside of them, in contrast with the flat *timbu wara*. While the Enga *yupin* practices and ideas are clearly cognate with the Wiru *wara* customs, the Wiru obviously developed their own ways of thinking about these objects.

Dosedla also briefly describes the Wiru *timbu wara* figures, which he says were painted with concentric rings of white and yellow with a background of red ochre. Such concentric rings are a significant motif for the Wiru. They appear on decorations women made around their navels for dances and in the bands of earth colours painted around the Female Spirit (*Aroa Ipono*) cult stones (Strathern & Stewart 1999b). He notes that they appeared only as the flat type, and not as animal but anthropomorphic forms. He suggests that the Wiru merged two types (the one seen in the East Kewa *Rimbu* cult and the other from the Enga area) into one type; that is, the Wiru figures were flat, not three-dimensional, but represented humans, not animals.

Ritual And Change

As Dosedla points out, the Wiru *timbu wara* figures belong to a wider geographical area in which similar figures were made for cult contexts. Dosedla traces the provenance of these figures and analyses their distribution in cultural–geographical terms. For our purposes here, it is important to ask how the Wiru figures were used in the wider contexts of cult and political activity; and also why they so rapidly ceased to be made if they held ritual importance, and what consequences ensued.

The name of these figures is significant. *Wara*, 'spear', refers to the context of warfare and inter-group conflict. The cult performers looked out on the spectators in order to demonstrate their political power and solidarity. *Wara* can also be used to mean 'wealth', the ability to 'kill' objects by paying for them with wealth items, or to obtain wives by the payment of bride price. As the figures represented the human form, they could ambiguously take onto themselves an aura both of the dead ancestors and of the living men who carried them in the festival. Since, among the Wiru, the *Tapa* cult dealt with internal problems

of sickness centered on male ancestors and the Female Spirit cult was concerned with general fertility and alliance, the space occupied by the *Timbu* cult clearly had to do with the outward-looking political strength of settlements.

The decline of the *Timbu* cult thus predictably accompanied the decline in warfare between parishes and hastened the demise of the pre-colonial patterns of inter-parish competition and display, although aspects of these continued in the pig-kills held periodically (Strathern & Stewart 1999a). In addition, as we have seen, some fundamentalist Christian missions in the 1960s were able successfully enough to label cult practices as satanic, and the *timbu wara* figures were prominent and easily visible targets for disapproval, whereas cult stones could more easily be hidden and used still for healing rituals or small sacrifices. The *timbu wara* figures thus disappeared, only to reappear briefly as 'tourist' objects, once emptied of their meaning and dislocated from their political and ritual contexts. Their decline is one of the markers of the success of colonial hegemony, with a trajectory from prime ritual object to tourist object to forgotten piece of knowledge.

Tracing the decline of these sacred figures through time, we have first to note that the major cult leaders were often those who surrendered their ritual power to the Christian missions in order to get the new ritual power that was on offer. In other words, they themselves in some sense began the process of desacralisation. Mission helpers then took this further by cutting the effigies into pieces, something their custodians themselves would not do because of *ela*. The same mission authorities, along with colonial government officers, completed the process by suggesting the items be made for sale, relying on people's desire for money.

The making of the figures for the Cambridge museum in 1967 pre-dated this process. These figures closely paralleled traditional designs. Those made later, for sale to tourists, showed variations. They were bigger, designed for display on hotel walls; more uniform in color and design; were turned out repeatedly; or were made in the shape of crosses or abstract designs. After Independence in 1975 and the departure of many expatriate missionaries and government officers, the people did not persist with this craft for long. Indeed, the figures were soon in over-supply: the patrol officer's space in the Pangia Station overflowed with them at one time, jumbled up and tangled together in disarray because of insufficient demand for them. As with other matters, the people became disappointed with their returns and ceased production.

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SEPIA HEDLEYI BERRY, 1918 (CEPHALOPODA: SEPIIDAE): A COMPLETE DESCRIPTION AND CLARIFICATION OF THE STATUS OF *S. DANNEVIGI* BERRY, 1918 AND *S. REX* (IREDALE, 1926)

A. L. REID

REID, A. L. 2001. *Sepia hedleyi* Berry, 1918 (Cephalopoda: Sepiidae): a complete description and clarification of the status of *S. dannevigi* Berry, 1918 and *S. rex* (Iredale, 1926). *Records of the South Australian Museum* 34(2): 79–97.

Following the examination of both qualitative and quantitative morphological characters, *Sepia dannevigi* Berry, 1918 from off Kangaroo Island, South Australia and *Sepia rex* (Iredale, 1926) from eastern Australia (Manly Beach, NSW) are synonomised with *Sepia hedleyi* Berry, 1918, also from off Kangaroo Island. These three species have never been satisfactorily delimited in the literature, so this synonomy is long overdue. A full redescription of *Sepia hedleyi* is provided.

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The cuttlefish *Sepia hedleyi* was described by Berry (1918) on the basis of a number of specimens collected from the Great Australian Bight, off the coast of South Australia. While the original description is detailed and relatively well illustrated, the cuttlebones of all the specimens were missing or damaged, and its structure was estimated in a reconstruction of the ventral side of the bone from fragments obtained from a single female specimen. In the same publication, another species from the same collection locality, *S. dannevigi*, was described on the basis of three female specimens, again with damaged cuttlebones.

Perhaps (in part) because the cuttlebones of these species were so incompletely known, another species, *S. rex*, was described by Iredale in 1926 on the basis of a cuttlebone collected on Manly Beach, Sydney (33°48'S 151°17'E). Iredale (1926) provided no justification for the erection of this new species: no comparison was made with other cuttlefish species. In addition, he placed *S. rex* in a new genus, *Decorisepia*, on the basis of its 'remarkable' rounded spine and the absence of an inner cone and ventral sulcus. Strangely, the two latter traits are clearly visible in his illustration accompanying the description (Iredale 1926: pl. xxii, figs 9–10) and are obvious on the type specimen. Following the comprehensive revision of the Sepiidae by Adam and Rees (1966), the validity of *Decorisepia* (and many other sepiid genera) has been questioned, and few workers follow this scheme, preferring to retain most sepiids within a single genus *Sepia* until more is known about the phylogenetic relationships among species. The generic classification of Adam and Rees (1966) is the one followed in this paper.

In a later work, Adam (1979) placed two other species, *Decorisepia cottesloensis* Cotton, 1929 and *D. jaenschi* Cotton, 1931, both known only from cuttlebones, in synonomy with *S. rex*. However, the description of *S. rex* in Adam (1979) is clearly that of yet another species, *S. opipara* (Iredale, 1926), so Adam's synonomy is not valid. After examining the type cuttlebones of all these species, Lu (1998) confirmed that *D. cottesloensis* and *D. jaenschi* are indeed synonyms of *S. rex*, so that part of the story, at least, has been resolved.

The three names, *S. dannevigi*, *S. hedleyi* and *S. rex*, have persisted in the literature until now, though they have never been satisfactorily differentiated from each other. Lu (1998) gave a diagnosis for each species based on his examination of the type specimens and comparison with other material housed in the Museum Victoria collections. The only difference he noted between *S. hedleyi* and *S. rex* is that the cuttlebone striae are nearly straight in *S. hedleyi* (based on Berry's figure of the reconstructed cuttlebone), but rounded in *S. rex*. He also noted the similarity between *S. dannevigi* and *S. hedleyi* and suggested they may be conspecific.

The aim of the present study is to clarify the status and identity of the three putative species, *S. dannevigi*, *S. hedleyi* and *S. rex*.

Materials And Methods

This work was based on museum material. The non-type material examined is listed in Appendix 1. Material examined in detail for both qualitative and quantitative characters is listed in the *Material examined* section of the species description below. Australian institutional abbreviations used are: AM, Australian Museum, Sydney; MV, Museum Victoria, Melbourne; SAM, South Australian Museum, Adelaide.

To determine whether *S. dannevigi, S. hedleyi* and *S. rex* are conspecific, the type specimens and their original descriptions were compared. In addition, specimens from close to the type locality of *S. rex* (Manly Beach, NSW, 33°48'S 151°17'E) were compared with specimens from southern Australia. Because the *S. rex* type specimen is a beachwashed cuttlebone, it may have drifted from any distance before reaching Manly Beach, so the selection of specimens for comparison is not entirely satisfactory, but unavoidable. Identification of these specimens could only be based on the appearance of the cuttlebones and their comparison with the type specimen.

Unfortunately, apart from the type specimens, no other material was available for study from the type locality of *S. dannevigi* and *S. hedleyi*, both from the 'Investigator St. Area, south of Kangaroo Island, South Australia' (Berry 1918: 263, 266). (Herein lies another difficulty: the Investigator Strait is actually north of Kangaroo Island, and no latitudes and longitudes are given in Berry's paper, so the exact type locality is unknown.) Some additional specimens were examined from sites that were as close as possible to Kangaroo Island, though some distance away (see Fig. 1). Apart from the appearance of the cuttlebone (see *Results* to follow), these specimens conformed in all other respects to Berry's (1918) descriptions and type specimens of both *S. hedleyi* and *S. dannevigi* (the two of which appear to be indistinguishable).

In addition to comparing qualitative characters, the statistics package 'Systat' (Systat Incorporated) was used to compare differences in morphometric characters between the populations from eastern Australia (ten males and ten females) and those from southern Australia (seven males and nine females). Sexes were treated separately.

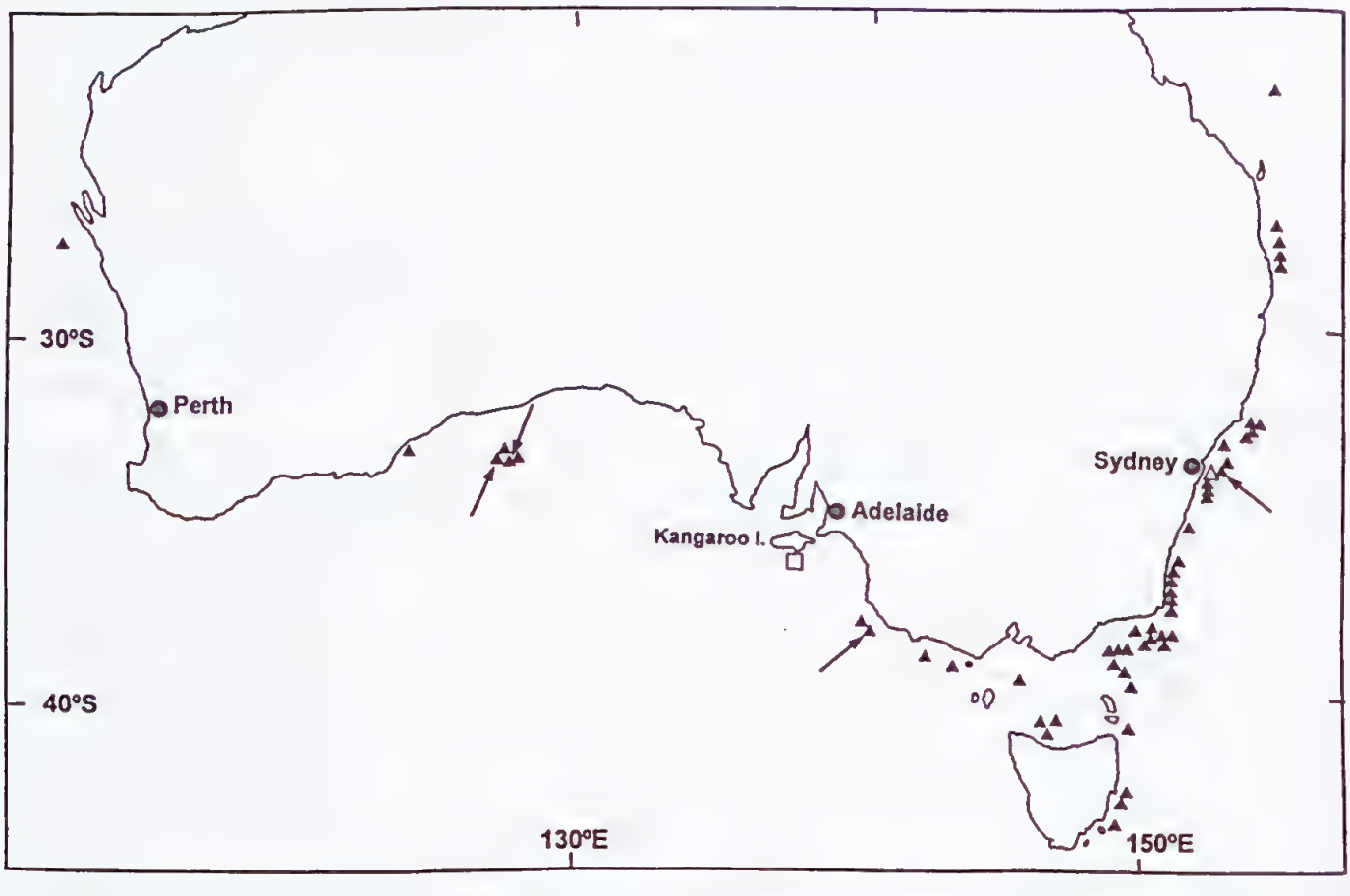

FIGURE 1. Distribution of *Sepia hedleyi* Berry, 1918 based on specimens examined in this study (solid triangles). The open square indicates the approximate type locality of *S. dannevigi* and *S. hedleyi* (see Materials and Methods), and the open triangle the type locality of *S. rex*. Arrows indicate the collection sites for specimens that were examined in detail for both morphological and morphometric characters.

In addition to preserved specimens, the measurements given in Berry's (1918) paper for *S. hedleyi* were included in the analyses. The measurements of one female specimen (E4377) were excluded for reasons given in the *Results* section below. Slopes and intercepts of regression equations were compared statistically between the eastern and southern Australian specimens for those characters showing a significant correlation with body size. For soft parts, mantle length was used as a size indicator. For cuttlebone measurements, cuttlebone length was used.

Measurements and indices used throughout this paper are primarily those given in Roper and Voss (1983), using dorsal mantle length (ML) as a size standard. Some additional measurements are used, and these with the definitions listed by Roper and Voss (1983) are given in Appendix 2. In the species description to follow, parts of the club and arm sucker rims are described using the terminology of Nixon and Dilly (1977) while nomenclature for the radula follows Nixon (1995). The beak was described following Clarke (1986). Diagrammatic illustrations of measurements and terminology used for key structures are shown in Reid (2000).

Measurements were made either using dial callipers, or an eyepiece micrometer inserted in a stereo microscope. All measurements are expressed in millimetres (mm). Measurements and counts for individual specimens and ranges of arm length indices, arm sucker diameter indices and arm sucker counts are presented in tables; ranges for all other characters appear in the text. In the species description and tables, the range of values for each character is expressed as: minimum–mean–maximum (standard deviation, SD). Values for each sex are given separately. Measurements were not taken from the *Sepia dannevigi* (AM C148249) or *Sepia hedleyi* (AM C148252) holotype specimens because of the poor state of preservation of these animals.

Measurements for structures that were clearly distorted or broken were not attempted; these, in addition to missing and unknown values, appear as a dash (–) in the appendices. Ranges for specific character traits given with the species description do not, therefore, always refer to the total number of specimens examined.

For examination of arm and club sucker rims, suckers were removed from the middle of designated arms and the tentacular club, mounted in glycerine jelly and viewed using a compound microscope. Radulae and beaks were dissected from the buccal mass and soaked for approximately 30 minutes in a warm, saturated potassium hydroxide solution; then radulae were cleaned using forceps and a fine brush. Radulae were mounted in glycerol and the new, unused portion was examined. All characters refer to both sexes unless stated otherwise.

The species description was generated using DELTA (DEscription Language for TAxonomy) software (Dallwitz, 1980; Dallwitz et al., 1993; Partridge et al., 1993).

Results

With a single exception, only minor differences were found between the type specimens and descriptions of *S. dannevigi* Berry, 1918, *S. hedleyi* Berry, 1918 and *S. rex* (Iredale, 1926). The exception is in the shape of the cuttlebone striae of *S. hedleyi* (Berry's figure pl. lxii, fig. 2, reproduced here as Fig. 2A), which are nearly straight compared with those of *S. rex* (Fig. 2C, D) which are an inverted U-shape (Fig. 2D). Unfortunately, the cuttlebone upon which Berry's illustration is based could not be found in the Australian Museum collection (Ian Loch, personal communication), so the accuracy of the reconstruction of the cuttlebone could not be checked. Assuming the shape of the striae as illustrated is true to the original specimen (a possibility that seems likely given that this section of the cuttlebone fragment is largely intact), a striking resemblance between this cuttlebone and that of another southern Australian species, *S. cultrata* Hoyle, 1885, is apparent (compare Fig. 2A and 2B). Females of *S. hedleyi* and *S. cultrata* are not easy to distinguish in most respects, however, the club suckers of *S. cultrata* are in 5–6 transverse rows and larger than those of *S. hedleyi*, which are in 9–12 rows. The tentacles were missing from the specimen Berry (1918) used for the illustration of the cuttlebone, so it is possible that this specimen may have been misidentified, and is actually *S. cultrata*. Both species inhabit similar depths and are often trawled together, so I believe this possibility is a real one. Given the doubt about the identity of the specimen (E4377, Berry's register [507]), its measurements were excluded from consideration in this study.

Morphometrics

Nine characters for males (MW, VML, FuL, HW, AS3, ASl4, ClL, ClSv and CbL) and 19 characters for females (MW, AMH, VML, HW,

TABLE 1. Morphological parameters showing differences in eastern and southern populations for females. Regression data $Y = a + bX$, where Y = dependent variable, a = intercept, b = slope, X = ML, Sig. = significant difference between the regression lines of eastern (E) and southern (S) Australian populations (Pop.) with respect to intercept, N = number of specimens, r^2 = proportion of total variation accounted for by regression.

Y	Pop.	N	r^2	a	b	Sig.
VML	E	10	0.922	0.46	0.88	$P < 0.001$
	S	8	0.882	18.65	0.61	
AS3	E	10	0.508	–0.23	0.02	$P < 0.05$
	S	5	0.833	–0.41	0.02	
ClL	E	10	0.748	–9.83	0.27	$P < 0.001$
	S	4	0.980	–11.91	0.35	

ED, AL1, AL2, AL3, AL4, AS2, AS3, AS4, ClL, ClSd, GiL, CbL, CbW, CbB and LoL) were significantly correlated with mantle length in both populations. Therefore, the slopes and intercepts of the regression equations could be compared statistically between the eastern and southern populations to determine whether there are any differences in these quantitative characters.

For males, no significant differences in either the slopes or the intercepts of the regression equations were found, suggesting that (for the characters that could be compared) the southern and eastern populations do not differ. Three characters differed between the eastern and southern populations in females: VML, AS3 and ClL (Table 1). To determine whether these differences are significant, or perhaps the result of geographic variation across the range of a single species, residual variables calculated for each of these characters were regressed against latitude and longitude of each specimen collection site following the methods detailed in Reid (1991). Residual values for VML and ClL were correlated with both latitude and longitude, indicating a strong geographic component in the difference between the eastern and southern populations (Table 2). The character AS3 was not correlated with either latitude or longitude and represents the only significant difference between the two populations in quantitative characters. A difference in this trait alone, the diameter of the suckers on the third arm of females, does not warrant further detailed investigation and is of not sufficient magnitude to warrant distinct species recognition.

One further difference was noted in the number of club suckers, with ClRC for the southern Australian population 9–10 (Appendix 3) and 11–12 for the eastern Australian population (Appendices 4 and 5), though the *S. hedleyi* holotype clearly has 12 suckers in transverse rows as noted by Berry (1918). While this does not appear to be a significant difference between the two populations, and given the difficulty in determining the exact number of club suckers, particularly in species where the suckers are small, it may still be worth investigating this character when more material from southern Australia becomes available.

From all available evidence, I conclude from the examination of both qualitative and quantitative characters that all specimens currently referred to as *S. dannevigi*, *S. hedleyi* and *S. rex* belong to a single species. Unless specimens are found that match all parts of Berry's (1918) description of *S. hedleyi*, including the shape of

TABLE 2. Latitudinal and longitudinal regression of residual variables pooled from female specimens from eastern and southern Australia tested by $Y = a + bX$ where Y = the predicted dependent variable, a = y intercept, b = slope, X is either latitude or longitude, N = number of specimens, r^2 = proportion of total variation accounted for by regression, N/S = not significant.

	X = Latitude					X = Longitude			
Variable	N	r^2	a	b	Sig.	r^2	a	b	Sig.
VML	28	0.511	54.40	–1.59	$P < 0.05$	0.360	–42.09	0.29	$P < 0.05$
AS3	25	0.217	–1.84	0.06	N/S	0.032	0.75	–0.01	N/S
ClL	28	0.670	–39.79	1.71	$P < 0.01$	0.354	23.61	–0.16	$P < 0.05$

the cuttlebone striae, I believe his illustration of the cuttlebone of *S. hedleyi* is in fact the cuttlebone of a specimen of a different species, probably *S. cultrata*. *Sepia hedleyi* has date precedence (ICZN, 1999: Art. 23.1) with respect to *S. rex*, and page precedence (ICZN, 1999: Art. 69A.10) with respect to *S. dannevigi*, so the latter two species are placed in synonomy with *S. hedleyi* in the description to follow.

Counts and indices for individual specimens from southern Australia are given in Appendix 3, and from eastern Australia in Appendices 4 and 5. Ranges for arm length indices, arm sucker diameter indices and arm sucker counts for southern Australian specimens are shown in Appendix 6. Measurements included in the description refer only to southern Australian specimens.

Taxonomy

Sepia hedleyi Berry
(Figs 1(in part)–7, Appendices 3, 6)

Sepia hedleyi Berry, 1918: 258–264, pls 71–72. – Lu, 1998: 169, fig. 10.

Sepia dannevigi Berry, 1918: 264–268, pls 73–74, figs 1–2. – Lu, 1998: 168, fig. 8.

Decorisepia rex Iredale, 1926: 193. – Lu, 1998: 180–181, fig. 22.

Material examined

Holotype. Sepia dannevigi, 1F (61.0 mm ML), Investigator St. Area, south of Kangaroo Is, South Australia, Jan–Feb 1912, FIS 'Endeavour' E2466 (AM C148249).

Holotype. Sepia hedleyi, 1M (56.9 mm ML), Investigator St. Area, south of Kangaroo Island, South Australia Jan–Feb, 1912, FIS 'Endeavour' E2464 (AM C148252).

Holotype. Sepia rex, 1 cuttlebone (107.0 mm CbL), Manly Beach, NSW [33°48'S 151°17'E] (AM C127593).

Other material examined. **Australia: New South Wales:** 1M (84.3 mm ML), 2F (83.1, 103.8 mm ML), 32°27'S 152°54'E, 244–242 m, 30 Jan 1982, coll. C. C. Lu & R. Tait (MV F77179); 1F (108.8 mm ML), 33°40'S 151°50'E, 210–204 m, 25 Jan 1982, coll. C. C. Lu & R. Tait (MV F77138); 5M (75.9–100.5 mm ML), 9F (72.6–107.7 mm ML), 33°42'S 151°51'E, 300–293 m, 25 Jan 1982, coll. C. C. Lu & R. Tait (MV F77136). **South Australia:** 3F (93.1–107.6 mm ML), 25.5

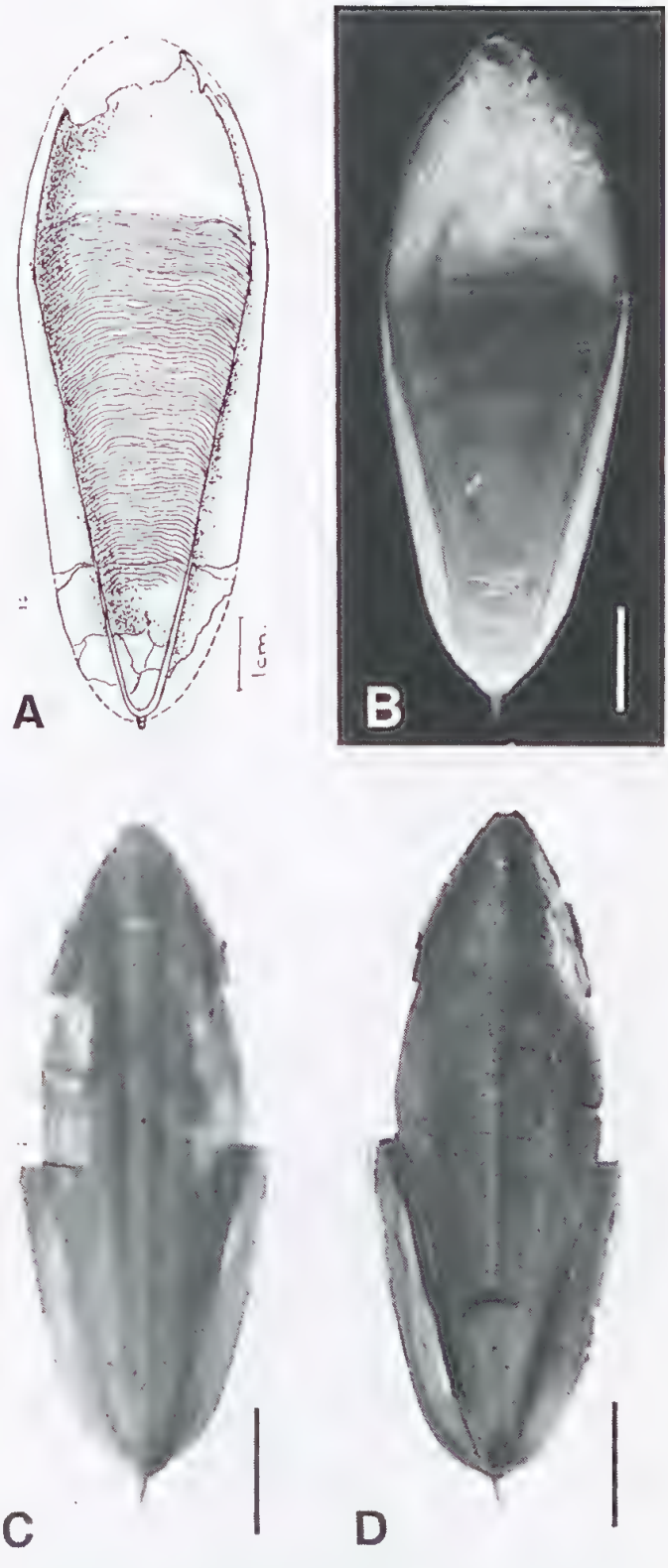

FIGURE 2. *A, Sepia hedleyi* Berry, 1918, reconstructed cuttlebone, pl. lxxii, fig. 2 Berry, 1918, female [507], 91.0 mm ML (E4377) (specimen possibly *S. cultrata* Hoyle, 1885); *B, Sepia cultrata* Hoyle, 1885, cuttlebone, ventral view, female, 67 mm ML (MV F66203); *C, Sepia rex*, cuttlebone, dorsal view, holotype, 107.0 mm CbL (AM C127593); *D, Sepia rex*, cuttlebone, ventral view, specimen as in *C*. Scale bars; A, B = 10 mm; C, D = 20 mm.

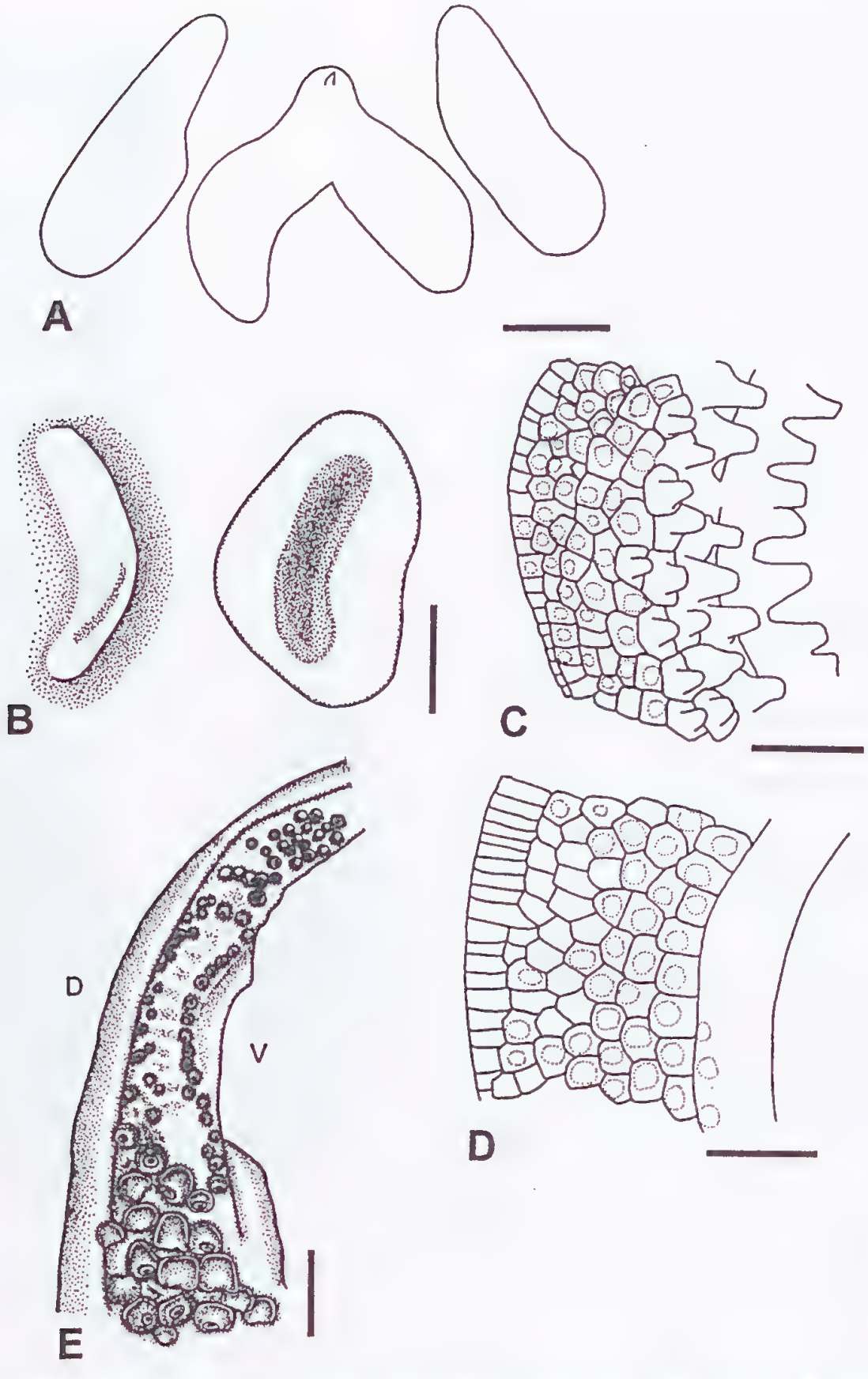

FIGURE 3. *Sepia hedleyi* Berry, 1918. *A,* funnel organ, male, 47.2 mm ML (SAM D19241); *B,* funnel-locking (right) and mantle-locking (left) cartilage, male, 47.2 mm ML (SAM D19241); *C,* sucker rim arm 1, portion of toothed half, male, 55.0 mm ML (SAM D19243); *D,* sucker rim, portion of non-toothed half, specimen as in *C*; *E,* portion of hectocotylised arm, male, 75.7 mm ML (SAM D19241) (D, dorsal; V, ventral). Scale bars; A = 5 mm; B = 2 mm; C, D = 0.05 mm; E = 2.0 mm.

miles [41 km] SW of Cape Buffon, 37°58'S 139°45'E, 300 fm [549 m], May 1981, coll. J. Sealey (SAM D19240). **Western Australia:** 2M (47.2, 75.7 mm ML), Great Australian Bight, 115 nm SW Eucla, 33°18'S 127°40'E, 180 m, 16 Jan 1989, coll. W. Zeidler & K. Gowlett-Holmes (SAM D19241); 2F (67.9, 68.6 mm ML), Great Australian Bight, 110 nm SW of Eucla, 33°19'S 127°50'E, 250 m, 16 Jan 1989, coll. W. Zeidler & K. Gowlett-Holmes (SAM D19242); 1M (55.0 mm ML), Great Australian Bight, 115 nm SW of Eucla, 33°19'S 127°50'E, 180 m, 16 Jan 1989, coll. W. Zeidler & K. Gowlett-Holmes (SAM D19243).

Diagnosis

Male and female arms subequal in length; arm suckers tetraserial throughout. Hectocotylus present, left ventral arm of males modified: 6–8 rows of normal suckers proximally, 9–10 rows of reduced suckers, remaining suckers normal to arm tip; suckers in two dorsal series smaller than those in two ventral series, dorsal and ventral series widely spaced, those in ventral two series aligned in a single row. Club with 9–12 suckers in transverse rows, all similar sized, small; dorsal and ventral protective membranes not fused at base of club; swimming keel extends well beyond carpus along stalk. Cuttlebone acute anteriorly and posteriorly, with median rib dorsally; spine without keels; anterior striae inverted U-shape; inner cone limbs uniform width, narrow, V-shaped posteriorly.

Description

Counts and indices for individual specimens are given in Appendix 3; ranges for arm length indices, arm sucker diameter indices and arm sucker counts are shown in Appendix 6.

Small to moderate-sized species; ML males 47.2–70.7–83.0 (SD, 13.9); females 67.9–87.8–107.6 (SD, 13.9). Mantle broad, oval; MWI males 41.9–49.8–55.6 (SD, 5.4); females 44.2–51.6–59.8 (SD, 5.9); dorsal anterior margin triangular, acute; extending anteriorly beyond eyes; AMHI males 11.9–14.2–15.5 (SD, 2.0); females 12.8–14.6–17.8 (SD, 2.0). Ventral mantle margin emarginate, without distinct lateral angles; VMLI males 80.7–86.0–93.7 (SD, 4.4); females 75.3–83.1–88.4 (SD, 4.5); posterior gland and gland pore absent. Fins widest in posterior third; FWI males 7.2–9.7–11.7 (SD, 1.3); females 4.4–8.6–11.6 (SD, 2.4); anterior origin posterior to mantle margin; FIIa males 4.5–5.0–5.3 (SD, 0.4); females 2.0–3.7–5.7 (SD, 1.5); rounded posteriorly; with narrow gap between; FIIp males 6.4–7.3–8.0 (SD, 0.8); females 4.7–7.9–12.4 (SD, 3.3). Funnel short, robust, broad; extends to level of anterior rim of eye; FuLI males 27.7–33.2–40.5 (SD, 5.5); females 25.6–30.0–34.6 (SD, 3.3). Funnel free portion approximately half funnel length; FFuI males 14.5–17.3–20.1 (SD, 2.8); females 12.6–15.3–19.3 (SD, 2.8). Funnel organ dorsal elements inverted V-shape with small anterior papilla; ventral elements oval with acute anterior tips (Fig. 3A). Mantle-locking cartilage curved, with semicircular ridge; funnel-locking cartilage with depression that corresponds to ridge (Fig. 3B). Head short; HLI males 17.6–23.2–29.7 (SD, 4.8); females 13.4–25.8–40.8 (SD, 9.4); broad, narrower than mantle; HWI males 33.8–37.8–44.4 (SD, 3.7); females 31.6–41.3–46.6 (SD, 5.1). Eyes moderate size; EDI males 12.7–14.2–16.5 (SD, 2.1); females 8.9–10.8–12.7 (SD, 1.6); ventral eyelids present.

Male and female arms subequal in length (Appendix 6). Arm length index (ALI) of longest arms in males (ALI4) 33.8–40.2–54.4 (SD, 7.2); ALI of longest arms in females (ALI4) 34.7–42.0–51.3 (SD, 4.8). Protective membranes in both sexes narrow. Non-hectocotylised arms normal, not thickened. Distal arm tips in both sexes not markedly attenuate. Arm sucker arrangement same in both sexes: arm suckers tetraserial. Male non-hectocotylised arm suckers normal in size (not greatly enlarged); smaller than female arm suckers in size (Appendix 6). Chitinous rims of arm suckers with elongate rectangular teeth on distal half of inner ring (Fig. 3C), teeth absent on proximal half of ring (Fig. 3D); infundibulum with 7–8 rows of hexagonal processes, inner 4–5 (variable) rows with elongate rounded pegs, pegs becoming smaller towards periphery of sucker; peripheral sucker rim processes radially arranged, elongate, without pegs.

Arm sucker counts range from 106 to 248; females with higher average counts than males (Appendix 6).

Hectocotylus present, left ventral arm modified; sucker size normal proximally, reduced medially, then normal to arm tip; from proximal to distal end of arm, 6–8 rows of normal suckers; 9–10 rows of reduced suckers (Fig. 3E). Suckers in two dorsal series smaller than those in two ventral series; reduced suckers much smaller than normal arm suckers: ASIn4 1.32–1.46–1.69 (SD, 0.20) *v.* ASInl4m 0.26–0.36–0.42 (SD, 0.09). Oral surface of modified region wide, swollen, fleshy, with transversely grooved ridges. Suckers in two dorsal and two ventral series displaced laterally, suckers

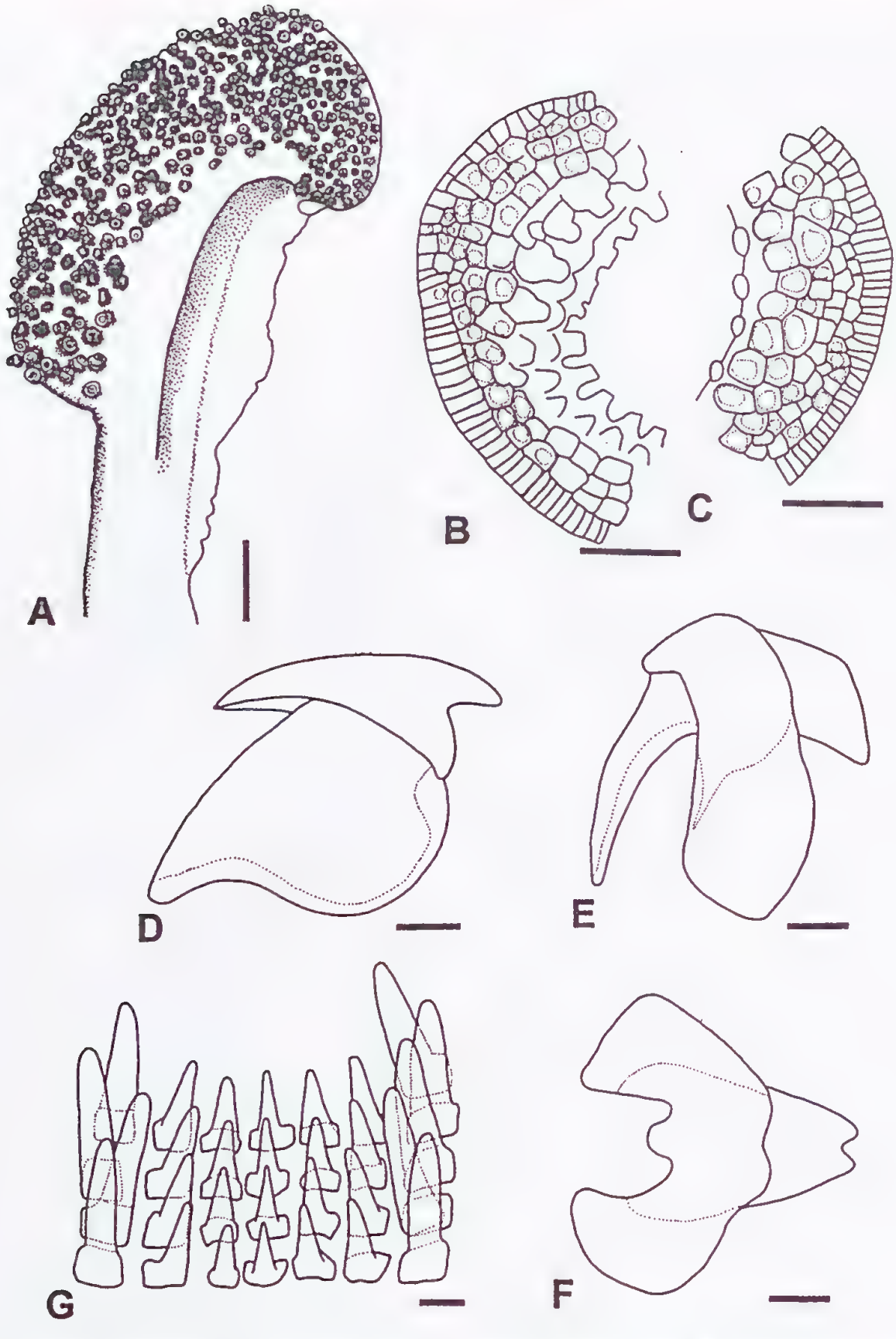

FIGURE 4. *Sepia hedleyi* Berry, 1918. *A*, club, male, 75.7 mm ML (SAM D19241); *B*, club sucker rim, portion of toothed half, male, 75.7 mm ML (SAM D19241); *C*, club sucker rim portion of non-toothed half, specimen as in *B*; *D*, upper beak, lateral view, female, 68.6 mm ML (SAM D19242) (stippling indicates extent of dark brown highly sclerotised portion of beak); *E*, lower beak anteriolateral view, specimen as in *D*; *F*, lower beak, ventral view, specimen as in *D*; *G*, radula, male, 75.7 mm ML (SAM D19241). Scale bars; A = 1.0 mm; B, C = 0.05 mm; D–F = 2.0 mm; G = 0.2 mm.

in two ventral series aligned in a single row (Fig. 3E). Hectocotylised arm not markedly attenuate distally.

Tentacular club longer in females than males; ClLI males 9.9–13.9–17.2 (SD, 2.8); females 16.2–20.0–24.2 (SD, 3.4). Club crescent-shaped; moderate length; sucker-bearing face flattened. Club with 9–12 suckers in transverse rows; 32–42 suckers in longitudinal series. Suckers all similar size; small (Fig. 4A). Distal tip of club with pair of slightly larger suckers partially covered by a thick, fleshy flap. ClSI males 0.40–0.45–0.53 (SD, 0.07); females 0.40–0.46–0.52 (SD, 0.05); dorsal and ventral marginal longitudinal series of suckers similar in size; ClSId males 0.40–0.42–0.42 (SD, 0.01); females 0.40–0.46–0.52 (SD, 0.05); ClSIv males 0.29–0.37–0.42 (SD, 0.07); females 0.32–0.41–0.52 (SD, 0.10). Sucker dentition: half inner ring circumference in both sexes with elongate-rectangular teeth (Fig. 4B), remaining half with blunt projections (Fig. 4C); infundibulum with 5–7 rows of hexagonal processes, innermost with elongate rounded pegs, pegs smaller towards periphery of sucker; at periphery, processes smaller, elongate-rectangular, without pegs (similar to arm suckers). Swimming keel of club extends well beyond carpus (Fig. 4A). Dorsal and ventral protective membranes not fused at base of club; joined to stalk; dorsal and ventral membranes same length; extend beyond carpus along stalk; approximately equal width; dorsal membrane forms shallow cleft at junction with stalk.

Gills with 29–30 lamellae per demibranch; GiLC males 29–29–29 (SD, 0); females 29–29–30 (SD, 0.7). Gill length: GiLI males 24.9–30.0–35.0 (SD, 5.0); females 29.5–33.9–38.2 (SD, 3.6).

Buccal membrane without suckers. Upper beak (Fig. 4D) rostrum pointed, short, length approximately equal to width, cutting edge

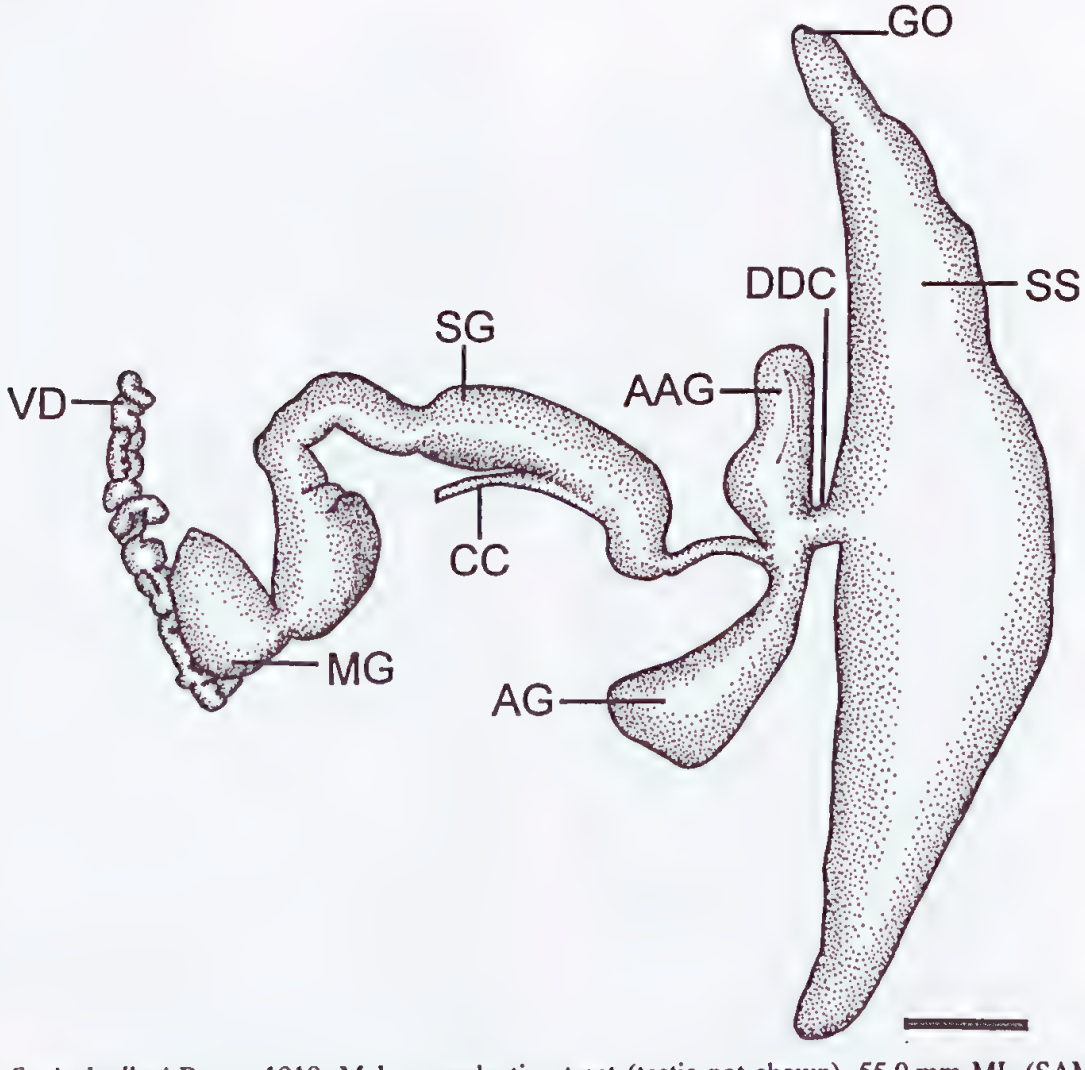

FIGURE 5. *Sepia hedleyi* Berry, 1918. Male reproductive tract (testis not shown), 55.0 mm ML (SAM D19243) (AAG, appendix of accessory gland; AG, accessory gland; CC, ciliated canal; DDC, distal deferent canal; GO, genital orifice; MG, mucilaginous gland; SG, spermatophoric gland; SS, spermatophoric sac (containing spermatophores); VD, vas deferens). Scale bar = 3 mm.

slightly curved; hood high above crest posteriorly; crest curved, lateral wall shallowly indented posteriorly; wings and hood narrow and short; jaw angle approximately 90 degrees; hood and crest dark brown. Lower beak (Fig. 4E, F) rostrum protrudes only slightly, cutting edge straight; hood low on crest; crest straight, no indentation on lateral wall edge; lateral wall edge angled posteriorly, not perpendicular to crest; hood and wings, width broad; hood notch shallow, broad; wings widely spaced; crest narrow; rostrum pigmented dark brown, wings dark brown on inner margin only, rest of wing light brown, crest dark brown. Radula (Fig. 4G) homodont; rhachidian teeth with truncate bases, slender, triangular, sides straight; first lateral teeth similar length and width to rhachidian teeth, asymmetrical with mesocone slightly displaced toward centre of radula; second laterals slightly longer than first, not distinctly curved on lateral margin, with broad heels; marginal teeth much longer than second lateral teeth, elongate with long tapered and curved mesocone. Digestive tract: (not illustrated) paired salivary glands approximately one-third length of buccal mass; paired digestive glands large, located close together, with narrow, elongate triangular lobes posteriorly, ducts connect digestive glands near midline with caecum, ducts with branched attached pancreatic tissue; oesophagus runs dorsally along median junction of digestive glands, joins sac-like stomach immediately posterior to digestive glands; caecum disc-like, grooved in a blunt V-shape anteriorly, surface lining finely pleated; intestine undifferentiated; ink sac very large, elongate; anal flaps well developed.

Male reproductive tract (Fig. 5): testis on left posterior side of viscero-pericardial coelom; at distal end, convoluted vas deferens opens into broad, cone-shaped mucilaginous gland, then narrower, curved, spermatophoric gland. Close to junction with lobe-shaped accessory gland and gland appendix, delicate ciliated canal joins spermatophoric gland; distal deferent canal connects appendix of accessory gland to spermatophore storage sac; genital orifice opens dorsal to left gill in anterior end of mantle cavity. Spermatophores (Fig. 6): cement body unipartite (not divided into distinct regions); flask-shaped, rounded posteriorly, connects to sperm reservoir via narrow duct; tapers abruptly following junction with middle tunic, which commences towards basal half of cement body; ejaculatory apparatus coiled, extends into oral dilation of spermatophore. Spermatophores 5.8–7.9 mm long; 0.2–0.4 mm wide; SpLI 10.4–11.5–12.3 (SD, 0.9); SpWI 3.4–4.4–5.1 (SD, 0.8). Buccal membrane in females extends ventrally with spermatheca.

Female reproductive tract: (not illustrated) ovary hangs from dorsal wall of posterior viscero-pericardial coelom. Oviduct thin-walled, continuous with body cavity; distally with thickened, glandular walls (oviducal glands). Nidamental glands in mature animals occupy large portion of ventral side of mantle cavity. Accessory nidamental glands anterior to nidamental glands. Eggs spherical; 2.5–3.1 mm diameter; EgDI 2.5–2.8–3.2 (SD, 0.4).

Cuttlebone length approximately equal to mantle length. Subdermal cartilaginous layer

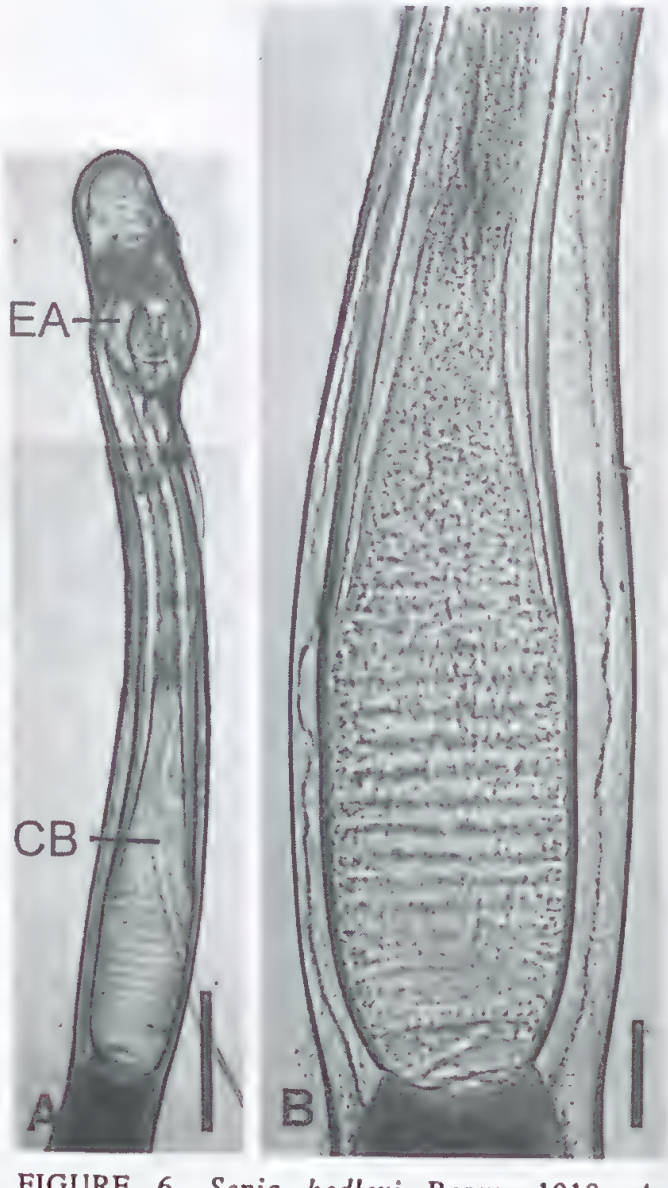

FIGURE 6. *Sepia hedleyi* Berry, 1918. *A*, spermatophore, oral end, male, 85.6 mm (MV F56762) (CB, cement body; EA, ejaculatory apparatus); *B*, enlargement of cement body, male, 90.0 mm ML (MV F57291). Scale bars; A = 0.15 mm; B = 0.10 mm.

between cuttlebone and skin absent. Cuttlebone outline oblong (Fig. 7); CbL males 46.2–50.6–55.0 (SD, 6.2); females 69.3–94.2–107 (SD, 16.9); CbWI males 34.7–36.4–38.1 (SD, 2.4); females 33.4–35.2–37.8 (SD, 2.0); not strongly convex in lateral view; CbBI males 9.6–10.0–10.4 (SD, 0.5); females 9.9–10.9–11.9 (SD, 1.1). Bone acuminate, acute anteriorly (Fig. 2C, D); acuminate, acute posteriorly (Fig. 2C, D and Fig. 7A, B); not strongly recurved ventrally. Dorsal surface creamy white; evenly convex; entire surface calcified with very fine granulose sculpture; spine and extreme posterior tip of bone covered with smooth glaze-like substance. Dorsal median rib present (Fig. 2C and Fig. 7A); distinct; sides approximately parallel, broaden slightly anteriorly; bordered laterally by distinct grooves; lateral ribs present, indistinct. Chitin surrounds entire margin of cuttlebone. Spine present; short, pointed; SLI females 4.7–4.9–5.1 (SD, 0.3); straight, parallel to bone; keel(s) absent; cuttlebone smooth between spine and outer cone; ventral notch at base of spine absent. Dorsoposterior end of cuttlebone without median longitudinal ridge anterior to spine. Striated zone flat; extends laterally to inner cone; not separated from outer cone by smooth marginal zones; StZI males 61.3–63.2–65.1 (SD, 2.7); females 64.1–65.5–66.8 (SD, 1.3). Last loculus convex; LoLI males 32.2–34.1–35.9 (SD, 2.7); females 28.7–30.8–33.6 (SD, 2.6); at midline half length of striated zone. LoL/StZ(%) males 49.4–54.0–58.7 (SD, 6.5); females 43.7–45.3–46.9 (SD, 2.2). Loculus ends at striated zone, does not extend posteriorly on each side of striated zone. Sulcus extends entire length of cuttlebone; shallow, narrow; not flanked by rounded ribs. Last loculus with shallow median indentation, not very pronounced. Anterior striae inverted U-shaped. Limbs of inner cone extend anteriorly to end of striated zone; inner cone lateral limbs not separated from outer cone by two distinct smooth zones. Inner cone limbs uniform width, narrow, V-shaped posteriorly; not raised to form ledge

FIGURE 7. *Sepia hedleyi* Berry, 1918. *A*, cuttlebone, dorsal view, female, 93.1 mm ML (MV F57307); *B*, cuttlebone, ventral view, specimen as in *A*. Scale bars = 10 mm.

posteriorly; thickened; shiny; without calcareous ribs radiating into outer cone. Outer cone present; calcified; moderate width; narrow anteriorly, broadens posteriorly; posteriolateral wall without, or with weak, indentation in both sexes; lateral limbs not flared ventro-laterally; limbs forming thin rim ventral to spine.

Body papillae present; dorsal mantle with longitudinal row of ridge-like papillae along each side, close to base of each fin; up to six fin papillae (approximately) in each row. Ventral mantle without ridges; head and arm papillae absent.

Ground colour (alcohol preserved specimens) pale buff pinkish-brown; arms without markings. Paired dorsal eye spots absent; fins pale. Fins without markings at base. Ventral pigment present, pale. Ridges orange-pink in colour.

Distribution

Australia: Queensland, from off the southern Great Barrier Reef, 22°35.3'S 153°46.7'E around southern Australia to Western Australia, SW of Shark Bay, 27°07'S 112°49'E. Depth range 47–1092 m (average collection depth 218 m).

Acknowledgments

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APPENDIX 1. Complete list of non-type material examined (not all specimens were sexed and are cited only as number in each specimen lot).

Australia: Queensland: 1, off GBR, 22°35.3'S 153°46.7'E, 350–345 m, 4 Nov 1985, coll. FV 'Soela' (MV F57306); 1F, off Brisbane, 26°40'S 153°41.9'E, 380 m, 2 Aug 1982, coll. M. Potter on 'Iron Summer' (MV F57294); 2, 27°11.48'S 153°43.9'E, 230–210 m, 14 Dec 1982, coll. G. Smith on 'Iron Summer' (MV F57299); 1, W Moreton I., 27°35'S 153°50'E, 210 m, 15 Dec 1982, coll. G. Smith on 'Iron Summer' (MV F57309); many 27°46'S 153°51'E, 205 m, 23 Mar 1983, coll. C. C. Lu on 'Iron Summer' (MV F57308); 1M, 1F, 27°58'S 153°49'E, 220 m, 23 Mar 1983, coll. 'Iron Summer' (MV F57300); many, off N Stradbroke I., 27°58'S 153°51.5'E, 183 m, 28 Jul 1982, coll. 'Iron Summer' (MV F89852); 1M, 9F, 32°23'S 152°49'E, 278 m, 30 Jan 1982, coll. C. C. Lu & R. Tait on FV 'Soela' (MV F77180); 10M, 6F, off NSW, 32°23'S 152°59'E, 278 m, 30 Jan 1982, coll. C. C. Lu & R. Tait on FV 'Soela' (MV F77191); 3M, 6F, 32°23'S 152°59'E, 278 m, 30 Jan 1982, C. C. Lu & R. Tait on FV 'Soela' (MV F77182); 7M, 5F, 32°24'S 152°56'E, 246–244 m, 30 Jan 82, coll. C. C. Lu & R. Tait on FV 'Soela' (MV F77084). **New South Wales:** 4, off Port Stephens, 32°24'S 152°56'E, 240 m, 30 Jan 1982, coll. FV 'Soela' (AM C152609); 2M, 10F, 32°27'S 152°54'E, 244–242 m, 30 Jan 1982, coll. FV 'Soela' (MV F77178); 1M, 2F, 32°27'S 152°54'E, 244–242 m, 30 Jan 1982, coll. C. C. Lu & R. Tait (MV F77179); 14, off Port Stephens, 32°50–52'S 152°42–41'E, 550 m, 6 Dec 1978, coll. K. J. Graham, W. B. Rudman & P. H. Colman on FRV 'Kapala' (AM C152641); 2, 8 mls E of Port Stephens, 101 m, 18 Aug 1975, coll. K. J. Graham & C. Short on FRV 'Kapala' (AM C100805); many, off Newcastle, 33°01'S 152°01'E–33°03'S 151°58'E, 121 m, 28 Oct 1993, coll. FRV 'Kapala' (MV F89853); 17, 33° 06'S 124°33'E, 28 Nov 1981, coll. FV 'Soela' (MV F89854); 4, off Sydney 33°33–36'S 151°59–57'E, 373–366 m, 21 Dec 1976. coll. K. J. Graham & P. H. Colman on FRV 'Kapala' (AM C105862); 1F, 33°40'S 151°50'E, 210–204 m, 25 Jan 1982, coll. C. C. Lu & R. Tait (MV F77138); many, 33°42'S 151°51'E, 300–293 m, 25 Jan 1982, C. C. Lu & R. Tait (MV F77136); many, off Sydney, 33°45–34'S 151°39–40'E, 143 m, 5 Dec 1978, coll. FRV 'Kapala' (AM C152596); many, E of Cronulla, 34°05–11'S 151°19–14'E, 132 m, 22 Apr 1975, coll. FRV 'Kapala' (AM C152594); many, E of Wollongong, 34°19–20'S 151°19–18'E, 161 m, 12 Dec 1978, coll. K. J. Graham, W. B. Rudman & P. H. Colman on FRV 'Kapala' (AM C152646); many, Wreck Bay, 35°13'S 150°41'E–35°12'S 150°44'E, 60–47 m, 20 Oct 1993, coll. FRV 'Kapala' (MV F89855); many, off NSW, 36°20'S 150°20'E, 130 m, coll. FV 'Soela' (MV F77164); 1, 34°22'S 151°23'E, 26 Mar 1981, coll. FV 'Soela' (MV F89856); 1F, 36°26'S 150°12'E, 104 m, 21 Apr 1981, coll. FV 'Soela' (MV F77207); 2, off Tathra 36°35'S 150°11'E–36°39'S 150°10'E, 117–115 m, 8 Dec 1993, coll. K. Graham on FRV 'Kapala' (MV F89857); 2M, 1F, 25 km SSE Merimbula, 36°56.5'S 150°11.8'E–36°54.1'S 150°11.9'E, 115 m, 5 Aug 1993, coll. RV 'Southern Surveyor' (MV F89858); 1F, NE Twofold Bay, 37°05'S 149°54'E, 29 Dec 1960, coll. R. Slack-Smith (MV F89859); several, off Eden, 131.7 m, FRV 'Kapala' (AM C174072); 5M, 8F, E of Disaster Bay, 37°24'S 150°17.5'E, 172–162 m, 2 Aug 1993, coll. FRV 'Southern Surveyor' (MV F89860). **Victoria:** 4, 38°01.7'S 150°04.9'E, 3 Feb 1985, coll. FV 'Soela' (MV F89861); 5, 38°02'S 150°05'E, 4 May 1984, coll. FV 'Soela' (MV F51887); 1M, 3F, 38°06'S 149°55'E, 270–267 m, 18 Jan 1982, coll. C. C. Lu & R. Tait (MV F77112); 4, 38°09.1'S 149°54.0'E, 3 Feb 1985, coll. FV 'Soela' (MV F89862); 4, 38°13'S 149°43'E, 4 May 1984, coll. FV 'Soela' (MV F51888); 3, 38°15.4'S 149°19.5'E, coll. FV 'Soela' (MV F89863); 2, 38°34.25'S 148°32.25'E, 24 Aug 1982, coll. MSL (MV F89864); 1F, E Bass Strait 38°34.3'S 148°16.1'E, 86 m, 6 Jun 1984, coll. P. Moulton, MSL (MV F89865); 1F, 18 mls S of Cape Nelson, 38°44'S 143°33'E, 152.9 m, 26 Aug 1975, coll. FV 'Sarda' (MV F56764); 1F, off Portland, 38°50'–51'S 141°46'–55'E, 54.8 m, 5 Mar 1980, coll. M. Gomon on 'Halcyon' (MV F30332); 3, 38°50'S 141°46'E, 6 Mar 1980, coll. 'Halcyon' (MV F30843); 1M, 1F, eastern Bass Strait, 38°53.05'S 148°24.2'E, 126–101 m, 8 Feb 1981, coll. RV 'Hai Kung' (MV F57310); 1F, 38°55.6'S 148°27.7'E, 210–150 m, 27 Aug 1994, coll. FRV 'Southern Surveyor' (MV F89866); many, 39°16'S 145°05.08'E–38°77'S 145°07.64'E, 65.9 m, 3 Feb 1981, coll. M. F. Gomon et al. on RV 'Hai Kung' (MV F89867); 1 juv., E Bass Strait, 39°28.4'S 148°41.8'E, 110 m, 28 Mar 1979, coll. HMAS 'Kimbla' (MV F57292); many, central Bass Strait, 39°44.55'S 143°33.82', 78.7 m, coll. C. C. Lu on 'Hai Kung' (MV F57296). **Tasmania:** 1M, S of Flinders I., 40°43.79'S 148°32.7'E, 58.6–54.9 m, 7 Feb 1981, coll. FV 'Hai Kung' (MV F57311); 1F, SE Tasmania, 42°42.8'S 148°24.4'E, 446 m, 26 Jun 1984, coll. FV 'Soela' (MV F52265); 4, 42°38'S 148°24'E, 23 Jun 1984, coll. FV 'Soela' (MV F52100); 3, 42°42.8'S 148°24'E, 26 Jun 1984, FV 'Soela' (MV F51908); 6, 42°43.7'S 148°22.3'E, 15 Jun 1984, coll. FV 'Soela' (MV F52099); 1F, off Tasmania, 43°38.9'S 147°49.4'E, 160 m, 16 Feb 1976, coll. K. Nesis on RV 'Dmitry Mendeleev' (MV F57307). **South Australia:** 4F, 27 nm SW of Beachport, 37°50'S 139°46'E, 1092 m, 24 Oct 1981, coll. M. F. Gomon & R. Wilson on 'Halcyon' (MV F52793); 1F, off Beachport, 37°51'S 139°48'E, 437–400 m, 24 Oct 1981, coll. M. F. Gomon & R. Wilson on 'Halcyon' (MV F51369); 2F, off Beachport, 180 fm [329 m], Apr 1981 (SAM D19239). **Western**

Australia: 1M, 1F, SW of Shark Bay, 27°07'S 112°49'E, 248–238 m, 3 Mar 1981, coll. M. F. Gomon on 'Hai-Kung' (MV F56762); 1F, Great Australian Bight, 12.0 km S of Middini Beach, 33°17.4'S 127°44.5'E–33°17.1'S 127°31.25'E, 180–167 m, 14 Feb 1990, coll. R. Poole on FV 'Comet' (MV F89868); 1F, Great Australian Bight, 33°20'S 128°10'E–33°22'S 128°08'E, 200 m, 29 Sep 1980 (MV F56763).

APPENDIX 2. Description of measurements and counts. Definitions largely follow Roper and Voss (1983). New or modified definitions are indicated by an asterisk (*). Indices (shown in square brackets) are calculated by expressing each measure as a percentage of mantle length or, for cuttlebone characters, cuttlebone length (unless otherwise specified).

Arm Length - **AL**: length of each designated (ie 1,2 etc) arm measured from first basal (proximal-most) sucker to distal tip of arm (Arm 1, dorsal; 2, dorso-lateral; 3, ventro-lateral; 4, ventral) [**ALI**].

Anterior Mantle to Head length *: **AMH**: dorsal length of mantle measured from anterior-most point of mantle to intersection of transverse line joining dorso-lateral mantle margin [**AMHI**].

Arm Sucker Count *: **ASC**: total number of suckers on each designated arm (eg.ASC2).

Arm Sucker diameter: **AS**: diameter of largest normal sucker on each designated (ie 1,2 etc) arm [**ASIn**]; **ASl4m*** diameter of smallest sucker on modified portion of left ventral arm of males [**ASInl4m**].

Cuttlebone Breadth*: **CbB**: greatest dorso-ventral width of cuttlebone.

Cuttlebone Length: **CbL**: dorsal length of cuttlebone along midline, including spine.

Cuttlebone Width: **CbW**: greatest lateral width of cuttlebone [**CbWI**].

Club Length: **ClL**: length of tentacular club measured from proximal-most basal suckers (carpus) to distal tip of club [**ClLI**].

Club Row Count: **ClRC**: number of suckers in transverse rows on tentacular club.

Club Sucker diameter: **ClS**: diameter of largest sucker on tentacular club [**ClSI**].

Club Sucker dorsal *: **ClSd**: diameter of largest tentacular club sucker in dorsal-most (closest to swimming keel) longitudinal row [**ClSId**].

Club Sucker ventral *: **ClSv**: diameter of largest tentacular club sucker in ventral-most (opposite swimming keel) longitudinal row [**ClSIv**].

Eye Diameter: **ED**: diameter of eye [**EDI**].

Egg Length *: **EgL**: length of egg [**EgLI**].

Egg Width *: **EgW**: width of egg [**EgWI**].

Free Funnel length: **FFu**: the length of the funnel from the anterior funnel opening to the point of its dorsal attachment to the head [**FFuI**].

Fin Insertion anterior *: **FIa**: anterior origin of fin measured from mantle margin to anterior-most junction of fin and mantle [**FIIa**].

Fin Insertion posterior*: **FIp**: measured between posterior junctions of fins with mantle [**FIIp**].

Funnel Length: **FuL**: the length of the funnel from the anterior funnel opening to the posterior margin measured along the ventral midline [**FuLI**].

Fin Width: **FW**: greatest width of single fin [**FWI**].

Gill Lamellae Count: **GiLC**: number of lamellae on outer demibranch including the terminal lamella.

Gill Length *: **GiL**: length of gill [**GiLI**].

Head Length: **HL**: dorsal length of head measured from point of fusion of dorsal arms to anterior tip of nuchal cartilage [**HLI**].

Head Width: **HW**: greatest width of head at level of eyes [**HWI**].

Loculus Length *: **LoL**: length of the last loculus (ventral anterior smooth zone of the cuttlebone) [**LoLI**].

Mantle Length: **ML**: dorsal mantle length. Measured from anterior-most point of mantle to posterior apex of mantle.

Mantle Width: **MW**: greatest straight-line ventral width of mantle [**MWI**].

Spine Length *: **SL**: length of spine [**SLI**].

Spermatophore Length: **SpL**: length of spermatophore [**SpLI**].

Spermatophore Width: **SpW**: greatest width of spermatophore. Spermatophore width index is expressed as a percentage of spermatophore length [**SpWI**].

Striated Zone length: **StZ**: length of striated zone of cuttlebone [**StZI**].

Transverse Row Count: **TrRC**: number of suckers in longitudinal series on tentacular club (counted from proximal-most basal suckers (carpus) to distal tip of club).

Ventral Mantle Length: **VML**: length of ventral mantle measured from anterior mantle margin at ventral midline, to posterior apex of mantle [**VMLI**].

APPENDIX 3. Measurements (mm), counts and indices of *Sepia hedleyi* Berry, 1918 from southern Australia.

Museum Reg. no.	SAM D19241	SAM D19243	SAM D19241	SAM D19242	SAM D19242	SAM D19240	SAM D19240	SAM D19240
SEX	M	M	M	F	F	F	F	F
ML	47.2	55.0	75.7	67.9	68.6	93.1	95.5	107.6
MWI	55.1	55.6	51.8	55.5	45.5	54.7	59.8	55.0
AMHI	11.9	15.5	15.3	14.7	13.0	12.8	14.8	17.8
VMLI	85.0	80.7	82.8	85.6	84.8	81.2	81.8	75.3
FWI	11.7	10.2	9.4	7.2	8.2	7.8	9.1	4.4
FIIa	5.1	4.5	5.3	2.8	3.2	4.9	5.7	2.0
FIIp	6.4	8.0	7.4	5.6	12.4	10.3	4.7	6.7
FuLI	40.3	34.5	27.7	34.6	34.3	25.6	30.4	28.8
FFuI	20.1	14.5	17.2	14.7	16.8	19.3	12.6	13.0
HLI	25.6	27.5	29.7	23.9	13.4	40.8	30.3	35.8
HWI	38.1	44.4	35.7	44.0	45.0	40.5	46.6	43.5
EDI	13.3	16.5	12.7	10.0	12.1	12.7	8.9	10.2
ALI1	33.9	34.5	35.7	33.1	34.3	37.6	49.2	42.3
ALI2	33.9	30.9	29.1	31.7	35.7	39.2	42.4	42.8
ALI3	38.1	33.6	29.1	37.6	34.3	41.4	44.0	43.7
ALI4	43.4	40.9	34.3	39.0	42.3	41.9	51.3	44.6
ASIn1	1.69	1.36	1.32	1.47	1.53	1.72	1.68	1.77
ASIn2	1.48	1.36	1.59	1.47	1.53	2.15	1.68	1.77
ASIn3	1.48	1.36	1.59	1.47	1.75	2.15	1.78	1.77
ASIn4	1.69	1.36	1.32	1.33	1.56	2.15	1.78	1.77
ASC1	118	112	116	148	144	106	106	144
ASC2	140	152	148	148	156	130	175	176
ASC3	148	132	144	200	172	157	164	172
ASC4	180	208	164	240	248	193	212	224
ASIn14m	0.42	0.40	0.26	–	–	–	–	–
ClLI	17.2	–	13.2	18.6	16.2	–	21.2	24.2
ClRC	10	10	10	10	10	–	9	10
TrRC	42	–	32	36	32	–	40	34
ClSI	0.42	0.40	0.53	0.40	0.47	–	0.52	0.46
ClSId	0.42	0.40	0.42	0.40	0.47	–	0.52	0.46
ClSIv	0.42	0.40	0.29	0.32	0.32	–	0.52	0.46
GiLC	29	29	29	29	30	–	–	–
GiLI	35.0	24.9	30.1	29.5	38.2	–	33.6	34.5
SpLI	12.3	11.6	10.4	–	–	–	–	–
SpWI	3.45	4.69	5.06	–	–	–	–	–
EgDI	–	–	–	–	–	2.7	3.2	2.5
CbL	46.2	55.0	–	–	69.3	100.5	99.8	107.0
CbWI	38.1	34.7	–	–	37.8	35.5	33.4	33.9
CbBI	10.4	9.6	–	–	11.8	9.9	10.2	11.9
SLI	–	–	–	–	–	4.7	5.1	–
StZI	61.3	65.1	–	–	66.8	65.6	64.1	–
LoLI	35.9	32.2	–	–	–	28.7	30.1	33.6
LoL/StZ (%)	58.7	49.4	–	–	–	43.7	46.9	–

APPENDIX 4. Measurements (mm), counts and indices of 10 male *Sepia hedleyi* Berry, 1918 from eastern Australia.

Museum Reg. no.	MV F77136	MV F77179	AM C152623	AM C152623	AM C152623	MV F77136	MV F77136	MV F77136	MV F77136	AM C152623
ML	75.9	84.3	84.8	85.7	86.1	87.0	90.9	91.7	100.5	103.5
MWI	53.0	49.2	50.7	48.4	49.2	54.6	51.7	54.1	48.1	46.6
AMHI	16.2	15.1	12.5	13.0	15.0	14.4	13.3	12.5	11.9	14.9
VMLI	88.8	88.3	89.2	91.4	87.8	90.9	90.4	88.3	81.9	88.3
FWI	9.6	11.4	9.4	10.5	8.2	10.5	12.7	9.8	5.6	10.9
FIIa	4.2	3.3	3.8	4.8	4.8	6.6	3.7	3.8	7.0	4.4
FIIp	5.8	3.0	5.8	5.6	7.7	7.5	5.5	8.2	4.5	8.6
FuLI	32.9	31.2	30.4	31.0	31.1	36.6	30.3	31.7	32.7	30.7
FFuI	14.5	15.4	15.2	17.7	15.2	18.4	15.4	20.7	16.8	13.0
HLI	30.4	23.3	31.7	27.3	31.6	30.9	23.7	30.9	30.3	26.5
HWI	38.3	38.7	35.1	36.6	36.5	40.9	40.9	38.8	–	34.3
EDI	15.5	11.0	13.2	14.0	11.0	12.0	13.1	15.7	12.5	12.3
ALI1	38.2	33.2	33.6	32.8	26.7	37.4	33.0	33.8	27.9	26.1
ALI2	34.3	32.0	30.7	31.5	25.6	37.4	34.1	31.6	27.9	32.9
ALI3	36.9	32.0	34.2	32.7	29.0	36.8	31.9	28.4	31.4	33.3
ALI4	40.8	37.4	36.6	30.2	30.8	40.2	34.1	37.6	40.6	32.8
ASIn1	1.54	1.59	1.42	1.27	1.21	1.64	1.43	1.42	1.42	1.22
ASIn2	1.45	1.48	1.13	1.33	1.02	1.49	1.43	1.56	1.42	1.28
ASIn3	1.37	1.48	1.49	1.46	1.30	1.64	1.43	1.56	1.42	1.39
ASIn4	1.45	1.48	1.27	1.25	1.11	1.64	1.43	1.42	1.42	1.16
ASC1	96	93	72	89	76	93	89	86	92	119
ASC2	136	128	105	106	93	126	124	120	135	121
ASC3	139	142	121	112	101	124	124	142	144	123
ASC4	204	202	171	151	102	185	178	196	–	140
ASInl4m	0.47	0.37	0.25	0.28	0.29	0.36	0.40	0.36	0.39	0.20
ClLI	13.7	15.5	15.3	17.4	14.2	16.1	15.8	15.5	15.8	19.8
ClRC	12	11	11	12	11	12	12	12	12	12
TrRC	36	32	31	31	36	34	35	33	35	39
ClSI	0.51	0.52	0.65	0.53	0.64	0.60	0.43	0.43	0.52	0.68
ClSId	0.51	0.66	0.65	0.46	0.64	0.45	0.35	0.35	0.52	0.53
ClSIv	0.38	0.52	0.35	0.42	0.35	0.45	0.43	0.39	0.39	0.48
GiLC	30	31	34	32	27	33	32	32	32	32
GiLI	30.3	26.0	27.9	30.9	33.7	33.6	26.7	29.8	–	22.2
SpLI	10.9	8.7	–	–	–	9.7	9.1	9.2	8.5	–
SpWI	3.15	3.01	–	–	–	4.62	3.15	4.62	4.55	–
CbL	75.8	85.1	84.8	–	–	86.5	92.7	90.0	100.2	101.6
CbWI	36.1	35.6	32.0	–	–	34.9	32.9	34.7	31.2	31.3
CbBI	10.0	10.5	10.0	–	–	9.5	9.2	9.9	10.0	9.0
SLI	–	4.3	4.1	–	–	–	2.8	3.0	3.9	2.6
StZI	63.6	60.2	59.0	–	–	46.6	66.1	61.7	65.0	64.5
LoLI	37.6	33.0	32.5	–	–	34.0	28.5	31.1	31.8	29.4
LoL/StZ (%)	59.1	54.9	55.2	–	–	73.0	43.1	50.5	49.0	45.6

APPENDIX 5. Measurements (mm), counts and indices of 10 female *Sepia hedleyi* Berry, 1918 from eastern Australia.

Museum Reg. no.	MV F77179	MV F77136	MV F77136	MV F77136	MV F77136	MV F77136	MV F77136	MV F77136	MV F77179	MV F77138
ML	83.1	89.0	91.7	94.7	99.1	99.4	99.8	102.1	103.8	108.8
MWI	51.9	52.2	52.1	51.3	53.7	46.7	51.9	58.1	47.1	51.5
AMHI	16.1	12.9	12.3	14.8	15.9	13.6	13.9	14.8	13.2	14.8
VMLI	85.0	91.0	91.1	89.2	86.0	90.0	89.7	87.9	86.6	88.8
FWI	12.0	10.1	11.7	11.9	11.6	12.4	10.5	11.0	9.6	7.4
FIIa	4.5	7.0	4.1	4.9	3.6	4.0	4.2	3.1	4.6	6.3
FIIp	13.7	8.4	4.3	6.7	6.6	7.1	5.1	2.8	4.5	7.2
FuLI	30.7	38.3	34.4	32.5	32.2	33.7	33.6	32.6	27.3	35.2
FFuI	16.8	15.7	17.4	18.5	18.2	18.1	16.5	16.7	15.4	13.3
HLI	27.0	21.3	37.1	26.1	27.7	36.2	39.1	27.5	26.8	26.4
HWI	39.4	36.4	39.8	38.5	39.9	41.6	40.7	39.5	38.8	36.5
EDI	12.4	12.4	14.1	11.7	14.3	13.6	12.4	16.4	13.0	12.8
ALI1	33.7	32.6	38.2	35.9	41.4	37.2	36.1	41.1	34.3	31.3
ALI2	34.9	30.3	34.9	32.7	40.4	34.2	36.1	38.2	32.8	35.8
ALI3	36.1	34.8	39.3	34.3	40.4	41.2	41.1	42.6	36.6	32.2
ALI4	39.7	42.7	37.1	39.6	46.4	46.3	38.1	44.1	40.5	41.4
ASIn1	1.56	1.46	1.34	1.58	1.84	1.70	1.56	1.40	1.42	1.43
ASIn2	1.56	1.61	1.48	1.52	1.84	1.70	1.56	1.66	1.45	1.49
ASIn3	1.56	1.46	1.48	1.48	1.84	1.63	1.69	1.66	1.36	1.55
ASIn4	1.72	1.53	1.48	1.52	1.71	1.70	1.69	1.66	1.45	1.55
ASC1	106	112	94	110	120	96	106	102	98	92
ASC2	138	133	158	166	156	156	162	170	142	138
ASC3	150	142	148	192	168	162	154	168	162	138
ASC4	178	162	192	227	204	206	214	110	214	171
ClLI	15.4	15.7	15.0	15.2	18.3	16.3	18.5	16.7	15.2	18.4
ClRC	12	12	12	11	12	12	12	12	12	12
TrRC	27	35	47	29	38	30	32	36	30	38
ClSI	0.67	0.51	0.43	0.57	0.32	0.71	0.45	0.64	0.72	0.53
ClSId	0.49	0.44	0.43	0.57	0.32	0.58	0.39	0.64	0.75	0.53
ClSIv	0.42	0.40	0.43	0.57	0.32	0.52	0.42	0.44	0.54	0.41
GiLC	28	33	32	30	35	28	31	28	33	30
GiLI	24.5	23.0	25.8	25.3	32.0	30.5	27.5	30.7	27.2	31.6
EgDI	3.9	4.1	5.0	5.3	4.4	4.8	3.4	3.9	4.8	3.3
CbL	82.1	87.0	89.0	99.7	98.0	99.2	96.6	105.2	104.9	108.0
CbWI	34.0	35.3	34.2	32.1	36.8	34.6	37.9	37.0	35.3	34.3
CbBI	10.0	–	10.1	11.2	9.4	10.9	10.1	9.5	10.0	9.6
SLI	3.3	–	–	3.3	3.2	–	3.0	4.6	4.9	–
StZI	65.0	–	79.4	79.4	67.3	65.4	67.7	63.1	63.5	64.6
LoLI	22.4	–	20.6	20.6	21.1	20.3	27.3	30.6	30.9	35.4
LoL/StZ (%)	34.5	–	25.9	25.9	31.4	31.0	40.4	48.5	48.6	54.7

APPENDIX 6. *Sepia hedleyi* Berry, 1918; ranges of arm length indices (ALI), arm sucker diameter indices (ASIn) and arm sucker counts (ASC) of mature males and females from southern Australia; N = number of specimens, min. = minimum, max. = maximum, SD = standard deviation.

	Males					Females				
	N	min.	mean	max.	SD	N	min.	mean	max.	SD
ALI1	7	25.3	34.9	55.7	9.8	8	30.6	37.4	49.2	6.2
ALI2	7	25.9	31.5	45.6	6.8	8	27.6	35.8	42.8	5.6
ALI3	7	29.1	33.5	44.3	5.8	8	30.6	33.7	44.0	5.2
ALI4	7	33.8	40.2	54.4	7.2	8	34.7	42.0	51.3	4.8
ASIn1	3	1.32	1.46	1.69	0.20	5	1.47	1.63	1.77	0.13
ASIn2	3	1.36	1.48	1.59	0.11	5	1.47	1.72	2.15	0.27
ASIn3	3	1.36	1.48	1.59	0.11	5	1.47	1.78	2.15	0.24
ASIn4	3	1.32	1.46	1.69	0.20	5	1.33	1.72	2.15	0.30
ASC1	3	112	115	118	3	5	106	130	148	22
ASC2	3	140	147	152	6	5	130	157	176	19
ASC3	3	132	141	148	8	5	157	173	200	16
ASC4	3	164	184	208	22	5	193	223	248	22

A NEW GENUS AND SIX NEW SPECIES OF DYTISCIDAE (COLEOPTERA) FROM UNDERGROUND WATERS IN THE YILGARN PALAEODRAINAGE SYSTEM OF WESTERN AUSTRALIA

C. H. S. WATTS & W. F. HUMPHREYS

WATTS, C. H. S. & HUMPHREYS, W. F. 2001. A new genus and six new species of Dytiscidae (Coleoptera) from underground waters in the Yilgarn palaeodrainage system of Western Australia. *Records of the South Australian Museum* 34(2): 99–114.

A new genus and six new species of stygobitic beetles of the family Dytiscidae, subfamily Hydroporinae, from relatively shallow calcrete aquifers in Western Australia, are described and figured. The new genus (*Nirripirti*) and species (*N. hinzeae*) are in the tribe Hydroporini, whilst the remaining species belong in the tribe Bidessini, namely, *Nirridessus challaensis, N. masonensis, N. fridaywellensis, N. pinnaclesensis* and *Tjirtudessus raesidensis*. The species are members of a rich, recently discovered, relictual stygofauna, predominantly of Crustacea and Oligochaeta, inhabiting calcretes lying along palaeodrainage channels. The new genus represents a significant taxonomic extension of the Australian stygobitic Dytiscidae, being the first Australian stygobitic member of its tribe. The new species represent a significant geographic extension of Australian stygobitic Dytiscidae into a new palaeodrainage channel unconnected with any previously examined. Each calcrete area examined contained a distinct assemblage of beetles often with two species in sympatry.

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The presence of an extensive stygofauna consisting of Crustacea, Oligochaeta and beetles of the family Dytiscidae living in near-surface aquifers of the Western Desert areas of Western Australia has recently been documented by us (Watts & Humphreys 1999, 2000). In this paper we report on significant geographic and taxonomic extensions to the known fauna of Dytiscidae.

In our two previous papers we described eleven species of Dytiscidae belonging to three genera all in the subfamily Hydroporinae. One genus, *Kintingka*, known from only one female specimen, could not unequivocally be placed in a tribe but the other two genera possessed the defining synapomorphy for the tribe Bidessini—two-segmented parameres. In the most recent collection reported on here most specimens again belonged in the same two Bidessine genera, *Tjirtudessus* and *Nirridessus*. A series of relatively large specimens from one location, however, had single segmented parameres and other morphological characters in both adults and associated larvae which place them in the tribe Hydroporini, the first underground members of this tribe to be recorded from Australia, although they are a major component of the stygodytiscidae worldwide (Spangler 1986).

The Raeside palaeodrainage system (Fig. 40), from which some of the latest specimens were collected, is unconnected to the drainage systems from which we earlier reported underground Dytiscidae (Watts & Humphreys 2000: Fig. 38); this represents a significant extension of the geographical, as well as the taxonomic range, of the Yilgarn stygofauna. As for the systems reported in our earlier papers, numerous specimens of Crustacea—bathynellids, harpacticoid and cyclopoid copepods, ostracods and oniscid isopods—and some Oligochaeta and Hydracarina were collected. As before, the beetles and larger stygofauna were restricted to aquifers in areas of calcrete, as is the stygofauna found in the northern parts of the Western Shield (Poore & Humphreys 1998; Humphreys 1999 in press). But, unlike our previous observation that the stygofauna was found only in narrow bores, thus seemingly restricted to 'closed' aquifers (Watts & Humphreys 2000), in this recent survey stygofauna were found to be common in formed-wells dug for water as well as in narrow bore-holes drilled for geological purposes, water monitoring, water pumping or aquifer assessment.

Methods

The collection methods and measurements of physicochemical parameters in the water were the same as in our previous papers (Watts & Humphreys 1999, 2000).

Abbreviations used:

BES Prefix for field numbers, WAM Biospeleology.

SAMA South Australian Museum, Adelaide.

WAM Western Australian Museum, Perth.

Systematics

Key to Australian Species of Stygobitic Dytiscidae

1. — Profemur with small peg-like structure close to base; metatibia approximately the same width throughout .... *Nirripirti hinzeae* sp. nov.
   — Profemur lacking such a structure; metatibia narrow at base then strongly expanding towards apex 2
2. — Body length approximately 1.0 mm; legs stout, without swimming-hairs on fore- and midlegs ..... *Kintingka kurutjutu* Watts and Humphreys
   — Body length > 1.2 mm; legs normal, all with swimming-hairs 3
3. — Third and fourth (apical) segments of labial palpi subequal in length; setae on hind edge of mesofemur not greatly stronger than those on mesotrochanter; length > 3.0 mm (*Tjirtudessus*) 14
   — Third segment of labial palpi half to two-thirds length of apical; setae on hind edge of mesofemur near base much stronger than those on mesotrochanter or elsewhere on femur; length 1.3–3.2 mm. (*Nirridessus*) 4
4. — Pronotal plicae strong, well marked 5
   — Pronotal plicae weak, difficult to trace 6
5. — Length of first two segments of metatarsi > rest; eye remnant present; parameres with long apical lobe .... *N. pulpa* Watts and Humphreys
   — Length of first two segments of metatarsi =< rest; without eye remnant; parameres with small apical lobe .... *N. morgani* Watts and Humphreys
6. — Length => 2.9 mm; eye remnant present; group of six spines close to base of mesofemur on hind edge .... *N. bigbellensis* Watts and Humphreys
   — Length < 2.6 mm; with or without eye remnant; spines on mesofemur spread out along hind edge or if restricted to base four or fewer 7
7. — Row of larger punctures adjacent to suture; metatrochanters rounded 8
   — Without sutural punctures, metatrochanters bluntly pointed 9
8. — Length 2.2–2.3 mm; with eye remnant .. *N. windarraensis* Watts and Humphreys
   — Length 1.3–1.5 mm; without eye remnant ..... *N. lapostaae* Watts and Humphreys
9. — Apical segment of antenna approximately the same size as penultimate, segments 3 and 4 subequal; pro- and mesotarsi strongly expanded, approximately equal in size .. .. *Nirridessus challaensis* sp. nov.
   — Apical segment of antennae approximately 1.5x length of penultimate, segment 3 > segment 4; protarsus moderately or weakly expanded, much more so than mesotarsi 10
10. — Mesofemur with four to five spines spread out along hind edge in basal half .... *Nirridessus masonensis* sp. nov.
    — Mesofemur with two to four strong spines clustered on hind edge close to base .. 11
11. — Mesofemur with four spines near base; segments 2 and 3 of antennae similar in size, apical segment approximately 1.5x penultimate in length ..... *Nirridessus cueensis* Watts and Humphreys
    — Mesofemur with two to three strong spines on hind edge near base; segment 2 of antenna large and oval, segment 3 much smaller and thinner, apical segment approaching 2x length of penultimate 12
12. — Mesofemur with two strong spines on hind edge near base; apical segment of paramere with two finger-like projections ..... *Nirridessus pinnaclesensis* sp. nov
    — Mesofemur with three strong spines on hind edge near base; apical segment of paramere with one finger-like projection 13

13. — Apical lobe of paramere overlapping rest of apical segment; central lobe pointed; protarsus weak, similar in size to mesotarsi; segment 3 of antenna >> segment 4 in length *Nirridessus fridaywellensis* sp. nov.
— Apical lobe of paramere well separated from rest of apical segment; central lobe blunt at tip; segment 3 of antenna > segment 4 in length; protarsus moderately expanded, mesotarsus less so ..... *Nirridessus hinkleri* Watts and Humphreys

14. — Pro- and mesotarsi strongly expanded; apical four segments of antennae noticeably thinner than others ..... *Tjirtudessus magnificus* Watts and Humphreys
— Pro- and mesotarsi only moderately expanded; apical four segments of antennae not narrower than others 15

15. — Length > 3.8 mm; pronotum a little narrower than elytra 16
— Length < 3.8 mm; pronotum wider than elytra ..... *Tjirtudessus eberhardi* Watts and Humphreys

16. — Metatrochanters rounded at tip; central lobe of aedeagus straight, tip pointed; with small eye remnant ..... *Tjirtudessus raesideensis* sp. nov.
— Metatrochanters pointed at tip; central lobe of aedeagus twisted, tip knobbed; without eye remnant ..... *Tjirtudessus hahni* Watts and Humphreys

Tjirtudessus Watts and Humphreys, 1999

Tjirtudessus raesideensis sp. nov.
(Figs 1–7)

Types

Holotype: m. 'BES 8354, Salt Well, Lake Mason Station, 27°32'24"S, 119°37'27"E, 24/6/00, coll W. F. Humphreys, S. Hinze' in spirit, WAM 27601.

Paratypes: 32, as for holotype, 19 SAMA, 13 WAM 27602–27615; 22, ditto except 'BES 8355', 10 SAMA, 12 WAM 27616–27627; 2, ditto except 'BES 8350', SAMA.

Description (number examined, 57)

Habitus. Length 3.5–4.0 mm; relatively flat, weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about half length of elytron.

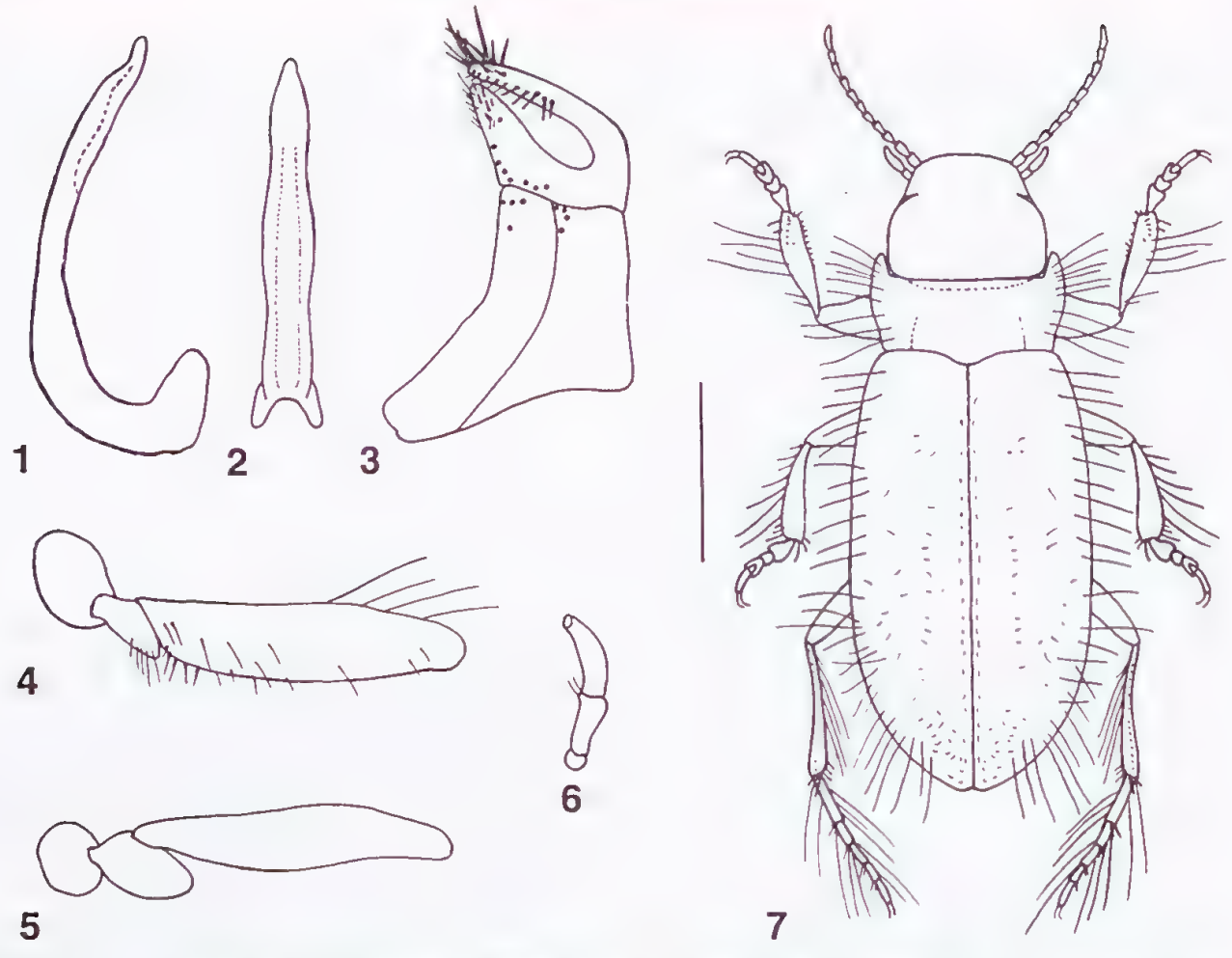
Head. Narrower than elytra; smooth, reticulation very weak, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to narrowly-oval structure. Antenna relatively stout; basal two segments cylindrical, third segment as long but narrower and narrowing towards base, next seven subequal but becoming progressively shorter, apical segment a bit longer than penultimate; each segment, except segment 1, with some very small setae on inside apically (Fig. 7). Maxillary palpus elongate, apical segment a little shorter than segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated. Labial palpus elongate, apical two segments subequal, tip weakly bifid, penultimate segment with two setae near tip (Fig. 6).

Pronotum. Almost as wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute; smooth, with sparse, very weak punctures and a row of stronger punctures along front margin; basal plicae moderately marked, straight, reaching to about halfway along pronotum, slightly excavated inwards; with row of long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with very small punctures, row of widely spaced larger punctures close to inner edge; numerous setiferous micropunctures towards apex and near base; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides. Epipleuron broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron.

Ventral surface. Prothoracic process strongly narrowed between coxae, not reaching mesosternum, apical half narrow, almost parallel-sided, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply triangular in front in midline, wings very narrow, broadly rounded in midline behind. Metacoxal plates large, metacoxal lines moderately widely spaced, reaching to about halfway to metasternum, evenly diverging; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines distinct towards midline, becoming indistinct laterally, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively narrow, inner edge



FIGURES 1–7. *Tjirtudessus raesideensis*: 1, lateral view of central lobe of aedeagus; 2, ditto dorsal view; 3, paramere; 4, mesotrochanter and mesofemur; 5, metatrochanter and metafemur; 6, labial palpus; 7, dorsal view. Scale bar represents 1 mm.

straight, outer edge bowed, widest past middle where it is about 3x its basal width; protarsi expanded, first segment broad narrowing at base, second segment a little narrower about one-third length of first, third segment as long as first but much narrower and very deeply bifid, fourth segment very small and hidden within lobes of third segment, apical segment narrow, cylindrical, about length of third, segments 1 to 3 with very dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with row of setae on inner edge; mesofemur with row of eight to nine relatively weak setae along hind edge in basal half (Fig. 4); mesotarsi similar to protarsi. Metatrochanter tip rounded (Fig. 5); metafemur elongate, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, basal segment longest, apical segment much longer than fourth, segments 1 and 2 in combination about as long as others; claws weak.

Male. Antennae a little stouter; pro- and mesotarsi a little stouter. Median lobe of aedeagus variable in width along shaft, tip bluntly pointed; paramere broad, apical segment with long, narrow, apical lobe well separated from rest of segment (Figs 1–3).

Etymology

Named after the palaeodrainage system in which it was collected.

Remarks

In size and in the relatively narrow pronotum, *T. raesideensis* most nearly resembles *T. hahni* but differs from this species in the more gracile fore- and midlegs, thinner antennae, more rounded tips to the metatrochanters and the presence of a small eye remnant which is absent in *T. hahni*. The aedeagi of the two species are quite different. It is smaller than *T. magnificus* with a narrower prothorax and much weaker pro- and mesotarsi. *Tjirtudessus eberhardi* is a little smaller with a broad pronotum and different aedeagus.

Nirridessus Watts and Humphreys, 1999

Nirridessus challaensis sp. nov.
(Figs 8–14)

Types

Holotype: m. 'BES 8319, Nyung well, Challa Station, 27°59'18"S, 118°31'03"E, 22/6/00, coll W. F. Humphreys, S. Hinze', slide mounted, in spirit, WAM 27668.

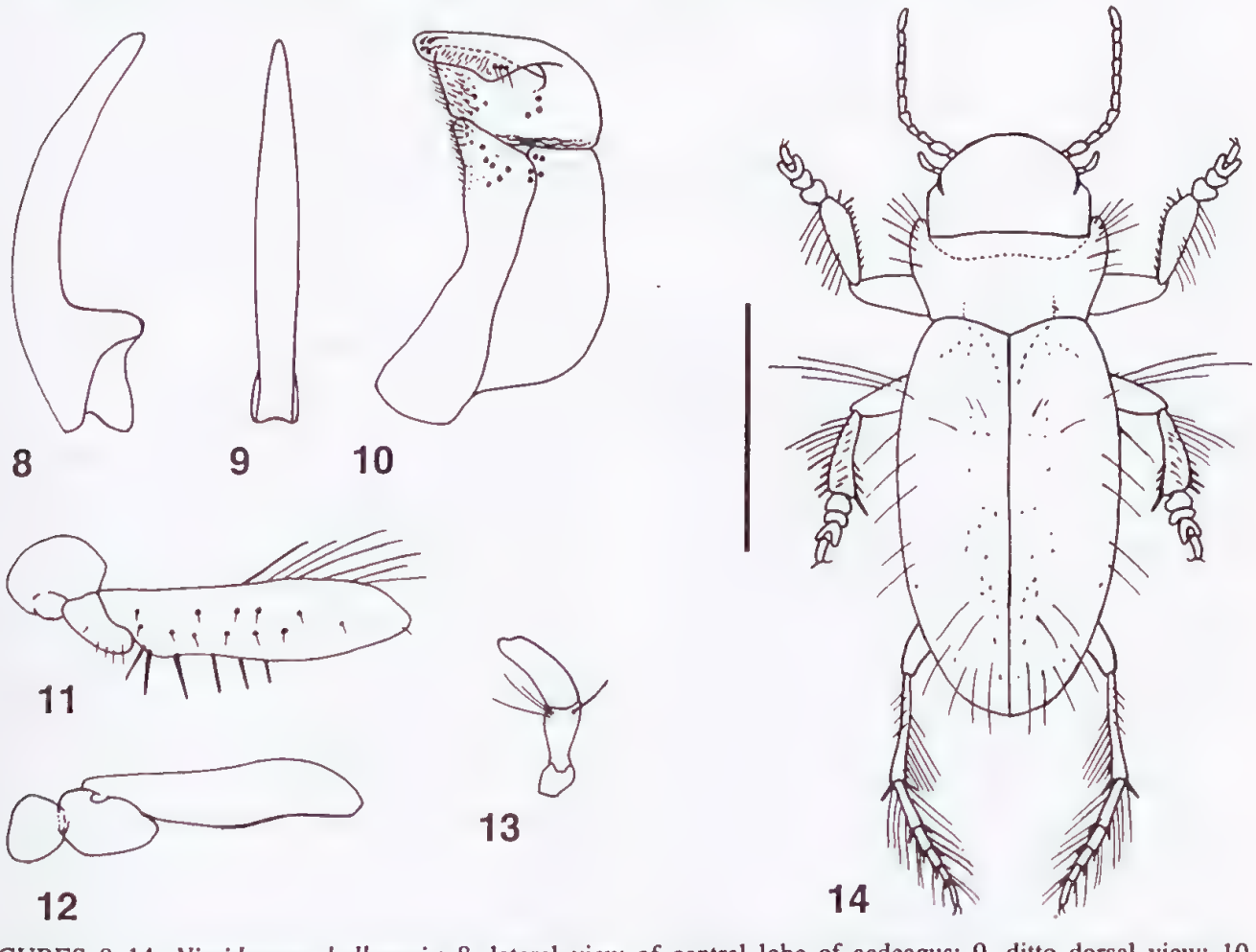
Paratypes: 1, as for holotype, WAM 27669; 3, 'BES 8346, Nyung well, Challa Station, 27°59'18"S, 118°31'03"E, 23/6/00, coll W. F. Humphreys, S. Hinze', 2 SAMA, 1 WAM 27671.

Description (number examined, 5)

Habitus. Length 2.3–2.5 mm; relatively flat, moderately constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about half length of elytron.

Head. Large, nearly as wide as elytra; smooth, weakly reticulate, a few small scattered punctures more numerous near antennal bases; subparallel in posterior half; eye remnant reduced to small triangular to oval area beneath head. Antenna relatively stout; basal segment cylindrical, second weakly ovoid, third segment about same length but narrower at base, fourth slightly smaller, next six subequal, apical segment a bit longer and slightly narrower than penultimate; each segment, except segments 1 and 4, with some very small setae on inside apically (Fig. 14). Maxillary palpus, elongate, apical segment large, about length of segments 1 to 3 combined, an oblique row of long setae on outer side near tip, tip truncated. Labial palpus moderate, apical segment longer that penultimate, tip weakly bifid, penultimate segment with small papilla near tip bearing two setae (Fig. 13).

Pronotum. Broad, as wide as elytra; anteriolateral angles projecting strongly forward; base moderately strongly narrowed, posterolateral angles acute; smooth, with sparse, very weak punctures more numerous towards the front margin; basal plicae very weak, slanting inwards, reaching to about halfway along pronotum, slightly excavated inwards; with row of long setae laterally, denser towards front.



FIGURES 8–14. *Nirridessus challaensis*: 8, lateral view of central lobe of aedeagus; 9, ditto dorsal view; 10, paramere; 11, mesotrochanter and mesofemur; 12, metatrochanter and metafemur; 13, labial palpus; 14, dorsal view. Scale bar represents 1 mm.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with scattered punctures larger laterally, row of small serial punctures in centre of elytron; setiferous micropunctures in basal fifth; a few scattered punctures with long setae, more frequent towards sides and apex. Epipleuron rather narrow in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron.

Ventral surface. Prothoracic process strongly narrowed between coxae, not reaching metasternum, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae nearly in contact at midline. Metasternum sharply triangular in front in midline, wings very narrow, broadly rounded in midline behind. Metacoxal plates large, metacoxal lines weak, widely spaced, reaching to about halfway to metasternum, diverging in anterior two-thirds; virtually impunctate except for a few towards midline; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines distinct, ventrites 3 to 5 mobile, virtually impunctate except for some small seta-bearing punctures towards anterior edge of ventrites, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively narrow, edges straight, widest near apex where it is about 3x its basal width; protarsi moderately expanded, first segment broadly oval, second segment as broad, about one-third length of first, third segment as long as first but narrower and very deeply bifid, fourth segment very small and hidden within lobes of third segment, apical segment narrow, cylindrical, about length of third, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter oval with row of fine setae on inner edge towards apex; mesofemur with row of five to six relatively weak setae along hind edge in basal half (Fig. 11); mesotarsi similar to protarsi. Metatrochanter weakly pointed (Fig. 12); metafemur elongate, lacking spines; metatibia curved, widening towards apex; metatarsi elongate, basal segment longest, apical segment a little longer than fourth, segments 1 and 2 in combination about as long as others; claws weak.

Male. Antennae a little stouter; pro- and mesotarsi a little stouter. Median lobe of aedeagus quite broad, weakly narrowing in apical quarter, tip blunt; paramere broad, apical segment with broad apical lobe folded over basal portion of apical segment (Figs 8–10).

Etymology

Named after Challa Pastoral Station, the location of the calcrete area in which it occurs.

Remarks

Nirridessus challaensis is a moderately large species without a row of large punctures adjacent to the suture. It can be recognised by the row of five relatively weak (for *Nirridessus*) spines on the mesofemur, the relatively broad pro- and mesotarsi, and by the antenna which has segments—including segments 3, 4 and the apical one—of approximately the same length.

Nirridessus fridaywellensis sp. nov.
(Figs 15–21)

Types

Holotype: m. 'BES 8379, Bore at Shearing Quarters, Depot Springs Station,

27°55'50"S, 120°04'45"E, 26/6/00, coll W. F. Humphreys, S. Hinze' in spirit, WAM 27628.

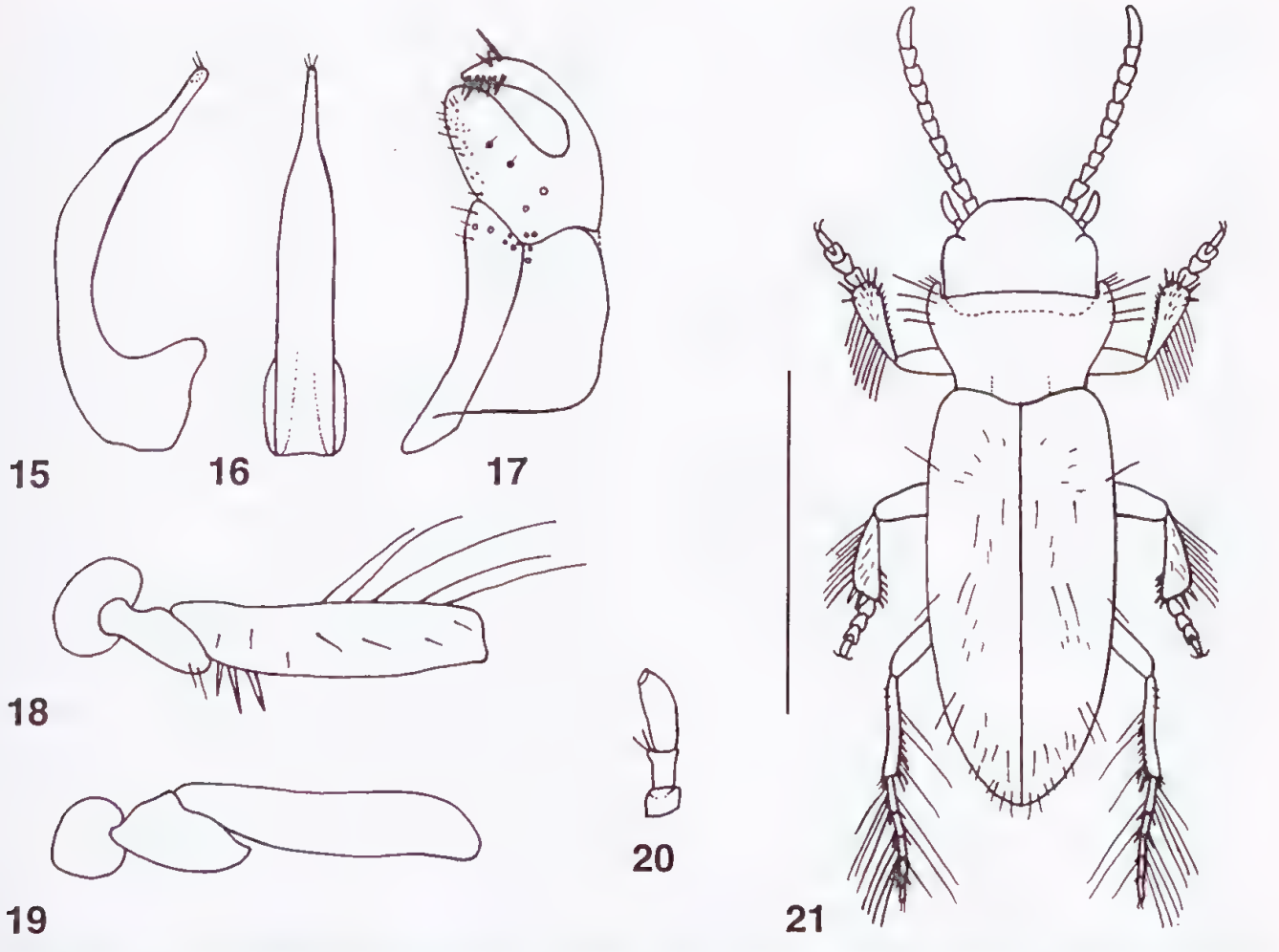
Paratypes: 2, as for holotype, 1 SAMA, 1 WAM 27629, slide mounted; 4, 'BES 8401, Site 425, Depot Springs, 28°03'00"S, 120°02'21"E, 28/6/00, coll W. F. Humphreys, S. Hinze', 2 SAMA, 2 WAM 27630–27631; 3,. 'BES 8406, Friday Well, Depot Springs, 28°03'36"S, 120°04'03"E, 28/6/00, coll W. F. Humphreys, S. Hinze', 2 SAMA, 1 WAM 27632, slide mounted.

Additional specimen: 1, f., 'BES 8374 Gums Well Depot Spring' SAMA. This specimen may also belong to this species but a male is needed to confirm the identification.

Description (number examined, 10)

Habitus. Length 1.7–1.8 mm; relatively flat, strongly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about quarter length of elytron.

Head. Relatively small, narrower than elytra; smooth, weakly reticulate, almost impunctate; subparallel in posterior half; sides with dark suture in middle near anterior edge. Antenna relatively stout; basal segment cylindrical, second large, oval, third segment almost as long, much narrower, narrowing towards base, next six subequal, apical segment about twice as long as penultimate; each segment, other than 1 and 4, with some very small setae on inside apically (Fig. 21). Maxillary palpus thin, elongate, apical segment large, a little shorter than segments 1 to 3 combined, oblique row of long setae on outer side near tip, tip truncated. Labial palpus moderate,



FIGURES 15–21. *Nirridessus fridaywellensis*: 15, lateral view of central lobe of aedeagus; 16, ditto dorsal view; 17, paramere; 18, mesotrochanter and mesofemur; 19, metatrochanter and metafemur; 20, labial palpus; 21, dorsal view. Scale bar represents 1 mm.

apical segment longer than penultimate, tip weakly bifid, penultimate segment with small papilla near tip bearing two setae (Fig. 20).

Pronotum. Narrower than elytra; anteriolateral angles projecting strongly forward; base strongly narrowed, posterolateral angles acute; smooth, with very sparse, very weak punctures more numerous towards the front margin; moderately reticulate; basal plicae absent; with row of long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges; elongate, widest behind middle, smooth, evenly covered with sparse very small punctures, central row of serial punctures hard to trace; some setiferous micropunctures near apex and along sutural line, very sparse or lacking at base; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides; moderately reticulate. Epipleuron broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron.

Ventral surface. Prothoracic process strongly narrowed between coxae, not reaching metasternum, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply triangular in front in midline, wings very narrow, broadly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate; moderately reticulate; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines distinct, ventrites 3 to 5 mobile, virtually impunctate except for ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively narrow, edges straight, evenly diverging, widest at apex where it is about 4x its basal width; protarsi little expanded, first segment oval, second segment as wide as about one-half length of first, third segment as long as first and as wide, deeply bifid, fourth segment very small and hidden within lobes of third

segment, apical segment narrow, cylindrical, about twice length of third, segments 1 to 3 with a few adhesive setae; claws short and simple. Mesotrochanter elongate oval with a few fine setae on inner edge; mesofemur with three strong setae/spines on hind edge close to base (Fig. 18); mesotarsi similar to protarsi. Metatrochanter weakly pointed (Fig. 19); metafemur elongate, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, basal segment longest, apical segment a little longer than fourth, segments 1 and 2 in combination about as long as others; claws weak.

Male. Antennae a little stouter; pro- and mesotarsi a little stouter. Median lobe of aedeagus relatively wide, narrowing rapidly in apical quarter into a long thin tip; paramere broad, apical segment with narrow, curved, apical lobe not, or only marginally, overlapping basal portion of apical segment (Figs 15–17).

Etymology

Named after one of the wells in which it occurs.

Remarks

Nirridessus fridaywellensis is a small *Nirridessus* with elytron lacking a row of serial punctures. It can be separated from similar species by the lack of pronotal plicae, three spines on the mesofemur and the form of the aedeagus.

Nirridessus masonensis sp. nov.
(Figs 22–28)

Types

Holotype: m. 'BES 8357, Salt Well, Lake Mason Station, 27°32'24"S, 119°37'27"E, 24/6/00, coll W. F. Humphreys, S. Hinze', slide mounted, WAM 27633.

Paratypes: 36, as for holotype, 16 SAMA, 20 WAM 27634–27653; 13, as for holotype except 'BES 8356', WAM 27654–27666; 1, as for holotype except 'BES 8354', WAM 27667; 8, as for holotype except for 'BES 8351', SAMA.

Description (number examined, 59)

Habitus. Length 1.6–1.9 mm; relatively flat, moderately strongly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, a bit over half length of elytron (Fig. 28).

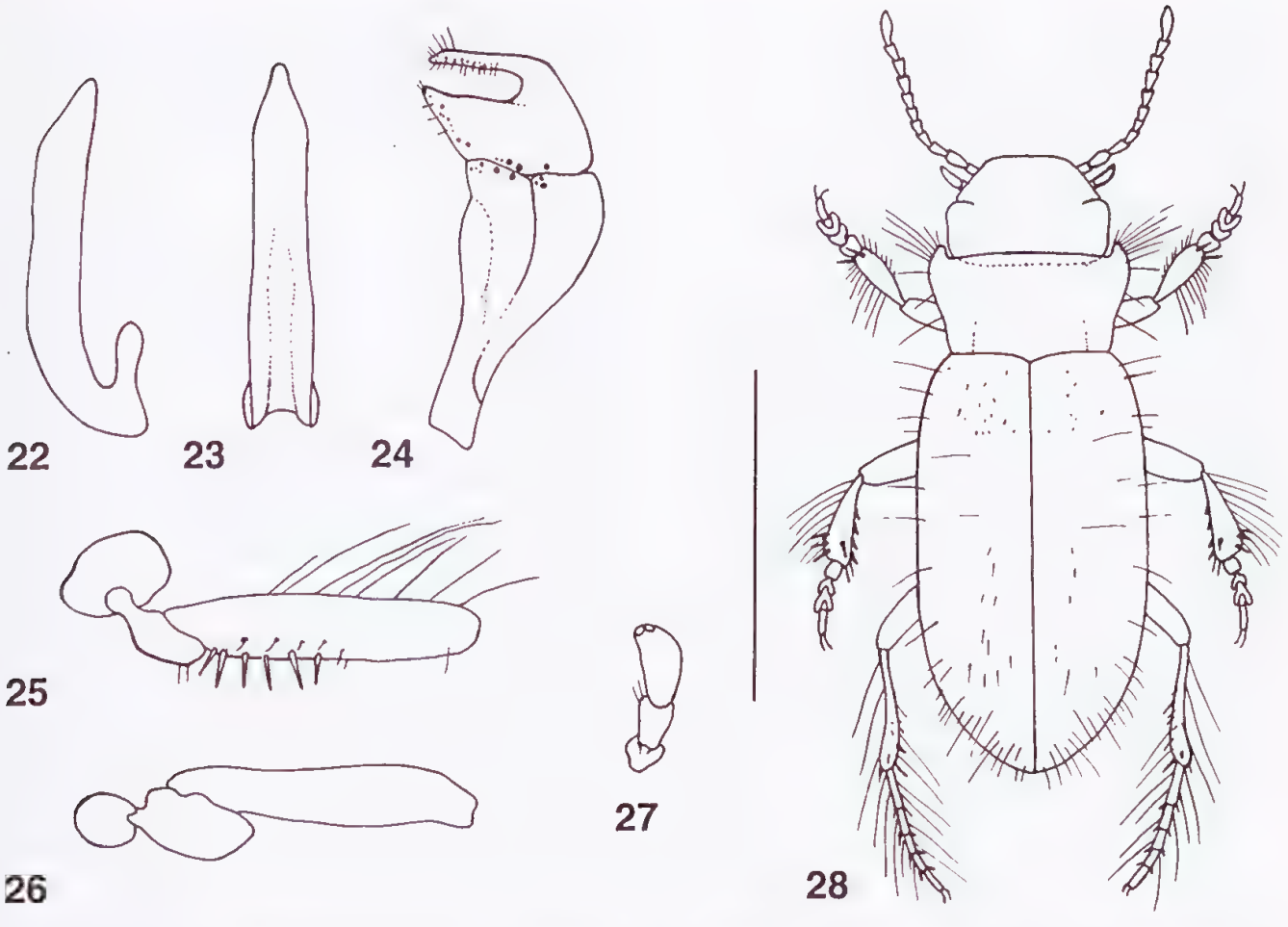
Head. Narrower than elytra; smooth, reticulation very weak, a few sparse small setae-bearing punctures; subparallel in posterior half; eye remnant reduced to single dark suture in middle near anterior edge. Antenna relatively stout; basal segment cylindrical, second large, oval, third segment shorter, narrower, narrowing towards base, fourth smaller, more parallel-sided, next six subequal, apical segment about twice length of penultimate; each segment, except segments 1 and 4, with some very small setae on inside apically (Fig. 28). Maxillary palpus elongate, apical segment large, a little longer than segments 1 to 3 combined, a diagonal row of long setae on outer side, tip truncated. Labial palpus moderate, apical segment longer than penultimate, tip weakly bifid, penultimate segment with small bulge near tip bearing two setae (Fig. 27).

Pronotum. A little narrower than elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute; smooth, with sparse, weak punctures more numerous towards front margin; basal plicae weak, reaching to about halfway along pronotum, slanting slightly inwards; with row of long setae laterally, denser towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with very small punctures, a row of serial punctures in middle of each elytron; setiferous micropunctures in basal fifth and near apex; row of long setae near lateral edge; a few additional larger punctures with long setae, more frequent towards sides. Epipleuron broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron.

Ventral surface. Prothoracic process strongly narrowed between coxae, not reaching metasternum, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly triangular in front in midline, wings very narrow, broadly rounded in midline behind. Metacoxal plates large, metacoxal lines very weak, widely spaced, reaching to about halfway to metasternum, diverging weakly in anterior third; virtually without punctures except for a few near midline; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural line distinct in inner half, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively narrow, inner edge straight, outer edge bowed, widest past middle where it is about 3x its basal width; protarsi weakly expanded, first segment reticulate, second segment as broad, about one-half length of first,



FIGURES 22–28. *Nirridessus masonensis*: 22, lateral view of central lobe of aedeagus; 23, ditto dorsal view; 24, paramere; 25, mesotrochanter and mesofemur; 26, metatrochanter and metafemur; 27, labial palpus; 28, dorsal view. Scale bar represents 1 mm.

third segment as long as first and as wide, moderately bifid, fourth segment very small and hidden within lobes of third segment, apical segment comparatively stout, cylindrical, about 1.5x length of third, segments 1 to 3 with covering of adhesive setae; claws short and simple. Mesotrochanter elongate-oval with one or two weak setae on inner edge; mesofemur with row of six to seven strong setae/spines along hind edge in basal half (Fig. 25); mesotarsi similar to protarsi. Metatrochanter bluntly pointed (Fig. 26); metafemur elongate, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, basal segment longest, apical segment a little longer than fourth, segments 1 and 2 in combination about as long as others; claws weak.

Male. Antennae a little stouter; pro- and mesotarsi a little stouter. Median lobe of aedeagus relatively wide, narrowing in apical quarter to blunt tip; paramere broad, apical segment with pronounced, narrow, apical lobe well separated from rest of apical segment (Figs 22–24).

Etymology

Named after the type location.

Remarks

Nirridessus masonensis is a small *Nirridessus* with the elytron lacking a row of large sutural punctures. It can be recognised by the relatively numerous well spread out spines on the mesofemur, obsolete lateral portion of the suture between the first and the second ventrite, and the long apical lobe to the paramere, which is well separated from the rest of the apical segment.

Nirridessus pinnaclesensis sp. nov.
(Figs 29–35)

Type

Holotype: m. 'BES 8397, Site 432, Pinnacles Station, 28°15'27"S, 120°07'37"E, 28/6/00, coll W. F. Humphreys, S. Hinze', slide mounted, WAM 27672.

Description (number examined, 1)

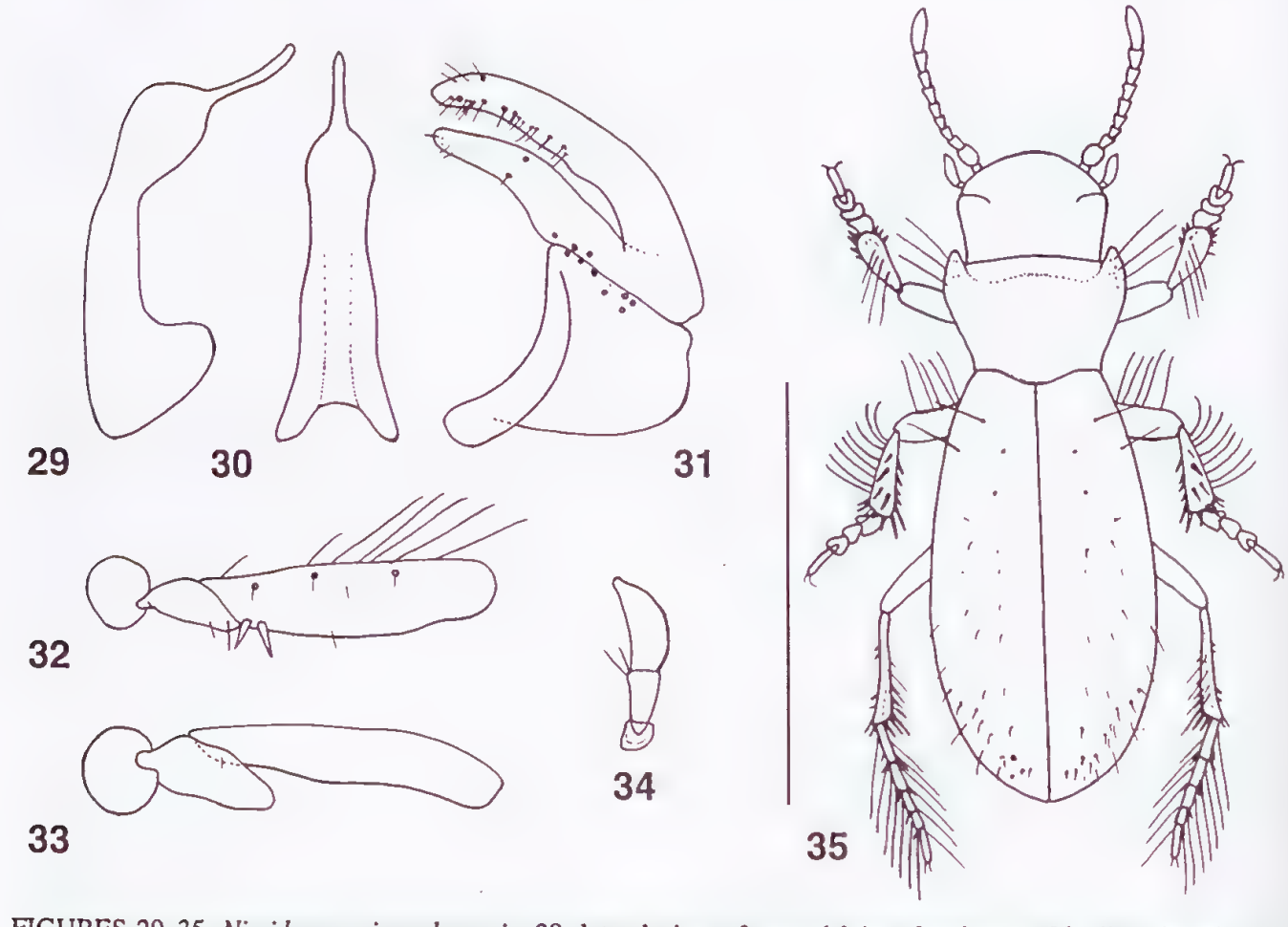
Habitus. Length 1.5 mm; relatively flat, strongly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about half length of elytron.

Head. Moderate, narrower than elytra; smooth, virtually without reticulation, virtually impunctate; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to broad dark suture in middle near anterior edge. Antenna stout; basal segment cylindrical, second almost round, third shorter, thinner, narrower at base, fourth about half length of third, next six subequal, apical segment twice as long as penultimate; each segment, except segments 1 and 4, with some very small setae on inside apically (Fig. 35). Maxillary palpus, elongate, apical segment large, a little longer than segments 1 to 3 combined, an oblique row of long setae on outer side towards tip, tip truncated. Labial palpus with apical segment longer than penultimate, tip weakly bifid, penultimate segment with small bulge near tip bearing two setae (Fig. 34).

Pronotum. About as wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute; smooth, virtually impunctate; basal plicae absent (or at least not traceable on mounted specimen); with some long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges; elongate, widest behind middle, smooth, weakly reticulate, very sparsely covered with small punctures, row of serial punctures in centre of elytron; setiferous micropunctures at apex, base and near suture; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides. Epipleuron broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron.

Ventral surface. Prothoracic process strongly narrowed between coxae, not reaching metasternum, apical half triangular, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply triangular in front in midline, wings very narrow, broadly rounded in midline behind. Metacoxal plates large, metacoxal



FIGURES 29–35. *Nirridessus pinnaclesensis*: 29, lateral view of central lobe of aedeagus; 30, ditto dorsal view; 31, paramere; 32, mesotrochanter and mesofemur; 33, metatrochanter and metafemur; 34, labial palpus; 35, dorsal view. Scale bar represents 1 mm.

lines long, moderate, widely spaced, reaching to about halfway to metasternum, weakly diverging; sparsely covered with small setae-bearing punctures; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines distinct, ventrites 3 to 5 mobile, very sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively broad, inner edges straight, widest past middle where it is about 3x its basal width; protarsi weakly expanded, first segment broadly oval, somewhat asymmetrical with outer side less expanded, second segment broad about one-half length of first, third segment as long and wide, quite deeply bifid, fourth segment small and hidden within lobes of third segment, apical segment narrow, cylindrical, about twice length of third, segments 1 to 3 with some adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae on inner edge; mesofemur with row of 2 very strong setae/spines on hind edge close to base (Fig. 32); mesotarsi less expanded than protarsi. Metatrochanter tip rounded (Fig. 33); metafemur elongate, row of small spines near inner edge; metatibia strongly curved, widening towards apex; metatarsi elongate, basal segment longest, apical segment a little longer than fourth, segments 1 and 2 in combination about as long as others; claws weak.

Male. Median lobe of aedeagus broad, apical quarter beak-like; paramere short, broad, apical segment formed into two long narrow lobes (Figs 29–31).

Etymology

Named after the Pinnacles Pastoral Station on which the specimens were found.

Remarks

Only one specimen is known of this small *Nirridessus.* Distinctive characters are the unusual beak-shaped central lobe to the aedeagus and two long lobes at the tip of the paramere, only two spines at the base of the mesofemur and short, stout antennae with a relatively long apical segment.

Nirripirti gen. nov.

Diagnosis/Description

Elongate—oval, relatively flat; eyeless; uniformly light testaceous; surface reticulate, meshes small, relatively even; punctures small, sparse; scutellum not visible dorsally. Pro- and mesotarsi pseudotetramenous; metatrochanters almost completely exposed, metafemur narrow, impunctate, metatibia relatively even in width. Pronotal process strongly arched, not reaching mesosternum; mesocoxae meeting. Male with one segmented parameres; central lobe of aedeagus simple.

Remarks

We place this genus in the Hydroporini on the strength of its relatively small size, lack of visible scutellum, straight even-width hind tibia, simple hind tarsi, simple even-sized hind claws, relatively narrow pronotal process, and single segmented parameres.

Its relationships within the Australian Hydroporini are not obvious. Its pseudotetramenous pro- and mesotarsi would seem to rule out *Sternopriscus* and *Necterosoma*; likewise, the shape of and lack of punctation on the metafemur would rule out *Megaporus, Antiporus, Tiporus* and *Sekaliporus.* By default as much as anything, we tentatively suggest that its sister genus could be *Paroster.* Its strong reticulation, elongate flattened shape and relatively simple aedeagus resemble some species in this genus but other characters, such as the elongate hind legs and lack of a basal epipleural stria on the elytra, negate any obvious relationship. A proper cladistic study, coupled with biochemical studies, will be needed to adequately determine its relations with other Australian genera.

Etymology

Western Desert Language; Nirri-nirri, beetle and pirti, well/shaft.

Type species

Nirripirti hinzeae sp. nov.

Nirripirti hinzeae sp. nov.

Types

Holotype: m. 'BES 8404, Friday Well, Depot Springs, 28°03'36"S, 120°04'03"E, 28/6/00, coll W. F. Humphreys, S. Hinze' in spirit, WAM 27673.

Paratypes: 3, as for holotype, WAM 27674–27676; 16, 'BES 8405, Friday Well, Depot Springs, 28°03'36"S, 120°04'03"E, 28/6/00, coll W. F. Humphreys, S. Hinze', 10 SAMA, 6 WAM 27677–27682.

Description (number examined, 20)

Habitus. Length 2.8–3.0 mm; elongate, relatively flat, slightly depressed in sutural region weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, reduced to tiny flap.

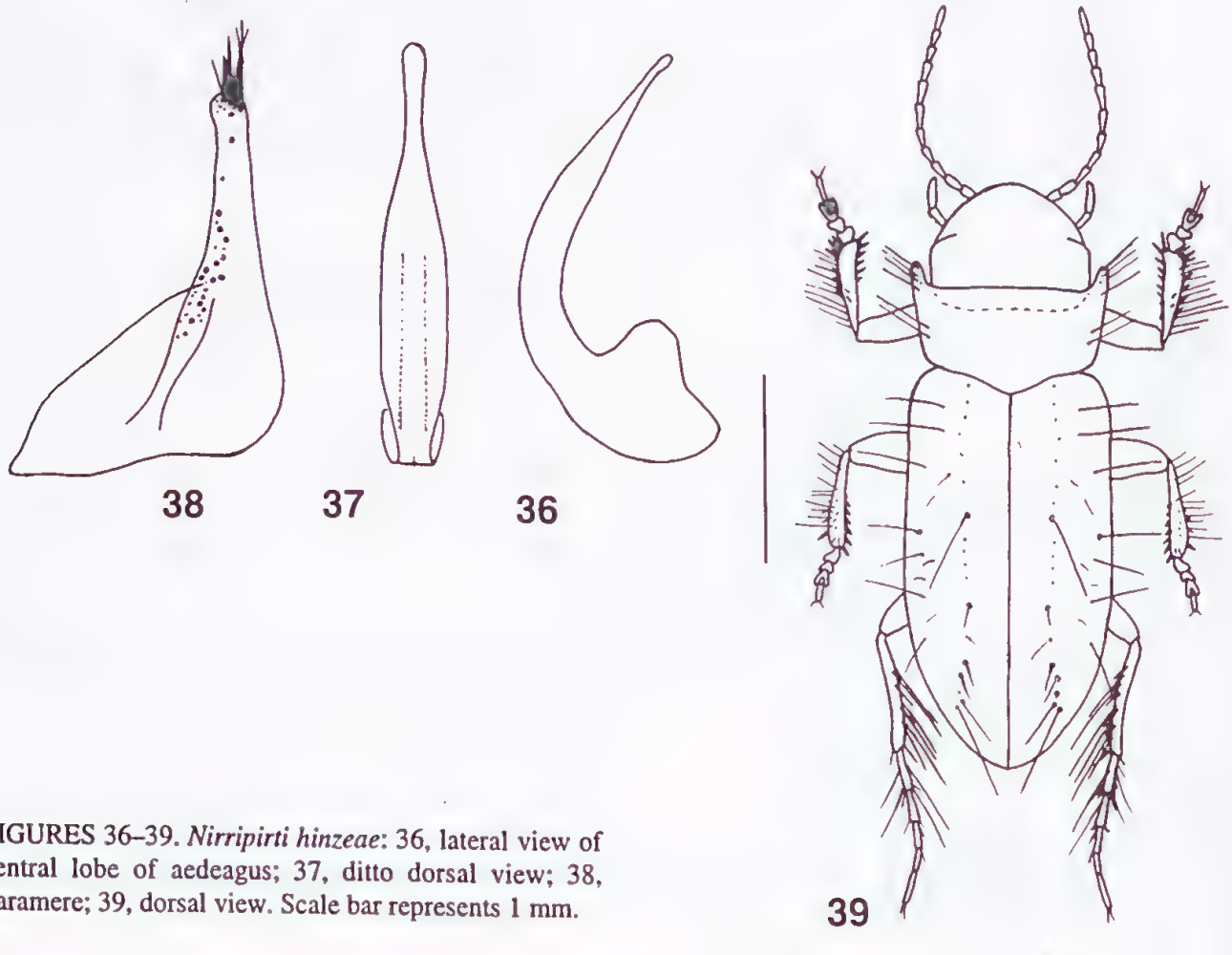
Head. Large, nearly as wide as elytra; smooth, moderately strong reticulation with small even meshes, virtually impunctate except a few near antennae bases; subparallel in posterior half; eye remnant reduced to a dark suture in middle near anterior edge. Antennal segments 3 to 5 thinner than rest, apical segment a bit longer and narrower than penultimate, each segment with some very small setae on inside apically (Fig. 39). Maxillary palpus elongate, apical segment longer than penultimate segment, some long setae towards apex of segments. Labial palpus with apical two segments subequal, tip weakly bifid.

Pronotum. Narrower than elytra; anteriolateral angles projecting strongly forward; base moderately narrowed, posterolateral angles obtuse; quite strongly reticulate, virtually impunctate except towards front margin; some long setae at edge towards front.

Elytra. Not fused, lacking inner ridges; elongate, widest behind middle, smooth, covered with fine reticulation; a few scattered small punctures, several rows of widely spaced small punctures; setiferous micropunctures at base, apex and along suture line, a few additional larger punctures with long setae, more frequent towards sides. Epipleuron very weakly differentiated from rest of elytron, broad in anterior quarter, then gradually narrowing to middle, virtually absent over rest of elytron.

Ventral surface. Prothoracic process strongly narrowed between coxae, not reaching metasternum, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly pointed in front in midline, wings very narrow, rather narrowly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines distinct in inner half, indistinct laterally, ventrites 3 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Profemur with small peg-like structure on



FIGURES 36–39. *Nirripirti hinzeae*: 36, lateral view of central lobe of aedeagus; 37, ditto dorsal view; 38, paramere; 39, dorsal view. Scale bar represents 1 mm.

hind edge adjacent to protrochanter; protibia narrow, widest past middle where it is about 3x its basal width; protarsi expanded, first segment broadly triangular, second segment about one-half length of first, third segment as long as first, deeply bifid, fourth segment very small and hidden within lobes of third segment, apical segment narrow, cylindrical, about length of third, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of four to five strong setae/spines along hind edge in basal half; mesotarsi similar to protarsi. Metatrochanter elongate/oval; metafemur elongate, lacking spines; metatibia weakly curved, approximately the same width throughout; metatarsi elongate, basal and apical segments longest, subequal, segments 1 and 2 in combination much shorter than others; segments 2 to 5 without spines other than at apex; claws weak.

Male. Little difference from female. Median lobe of aedeagus narrowing rapidly in apical quarter; paramere broad at base, apical half thin, tip with a bunch of long setae. (Figs 36–38).

Etymology

Named after Susan Hinze, the co-collector of the specimens.

Discussion

Site characteristics and associated fauna

The material treated here represents the results of sampling from 89 sites, of which 44 were narrow tube bores and 45 were open pastoral wells. Thirteen of these sampling sites yielded Dytiscidae, seven from wells and six from bores (Fig. 40). Both Amphipoda and Ostracoda were taken from 19 sites, and Copepoda (cyclopoid and harpacticod) from 12 sites. All Dytiscidae were taken from calcrete aquifers. The dytiscids occur in a stygal assemblage that includes other dytiscid

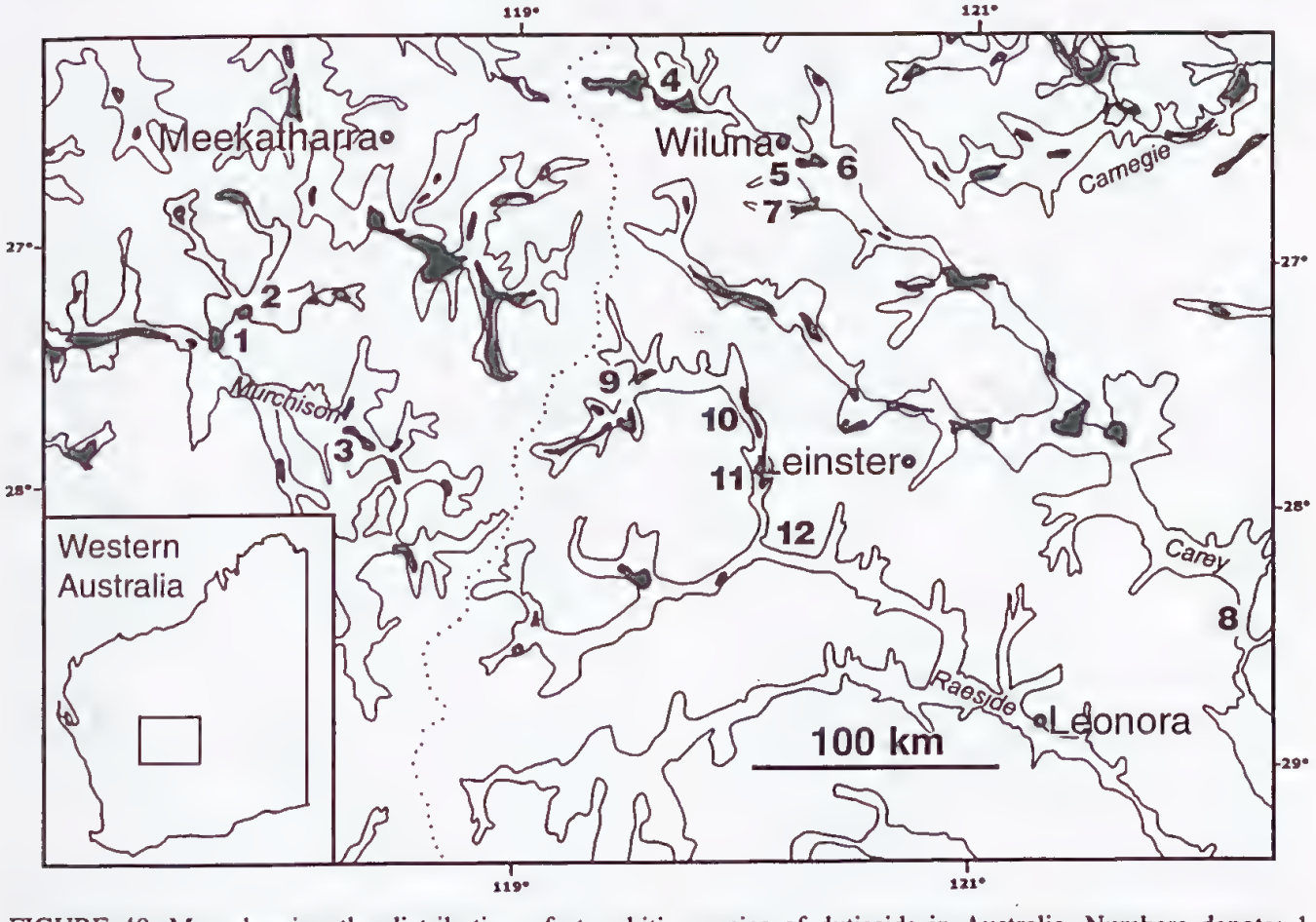


FIGURE 40. Map showing the distribution of stygobitic species of dytiscids in Australia. Numbers denote: 1, Austin Downs; 2, Cue; 3, Challa north; 4, Paroo; 5, Lake Violet; 6, NE Lake Way; 7, Hinkler Well; 8, Mount Windarra; 9, Lake Mason north; 10, Depot Springs north; 11, Depot Springs south; 12, Pinnacles. Outlined areas denote undifferentiated sediments in the palaeodrainage channels, while shaded areas denote calcrete. The northerly trending dotted line denotes the divide between the Indian Ocean and inland drainages (Beard 1998). Drawn from Geological Survey (1989).

TABLE 1. Taxa taken from the same wells as the dytiscid species

Dytiscid species	Sympatric taxa
Nirridessus challaensis	Amphipoda, Ostracoda, Copepoda, verms
Nirridessus fridaywellensis	*Nirripirti hinzeae*, Amphipoda, Ostracod, Copepoda, Bathynellacea, verms
Nirridessus masonensis	*Tjirtudessus raesideensis*. Amphipoda, Copepoda
Nirridessus pinnaclesensis	–
Tjirtudessus raesideensis	*Nirridessus masonensis*. Amphipoda, Copepoda
Nirripirti hinzeae	*Nirridessus fridaywellensis*. Amphipoda, Ostracoda, Copepoda.

species, amphipods, bathnellid syncarids, ostracods, cyclopoid and harpacticod copepods, and phreodrilid oligochaetes whose diversity has yet to be examined (Table 1). In other calcrete aquifers of the Western Shield of Australia, sympatry of congeners of various crustaceans is common (Bradbury 2000).

Water quality

The electrical conductivity of the water from which the Dytiscidae were recorded varied from 3.9 to 12.3 mS/cm, a salinity of approximately 2.3–7.3 g/L total dissolved solids (Table 2). While these waters are saline, they do not approach the high salinity, around 22 g/L, found near Lake Way (Watts & Humphreys 2000). However, the surface water may have been diluted by fresh water owing to unusually high rainfall in the six months prior to sampling; shallow calcrete aquifers are responsive to periodic recharge through the karst and may exhibit marked changes in both water level and salinity (Watts & Humphreys 2000). The pH and oxygen levels were within the range previously recorded for the stygobit Dytiscidae (Watts & Humphreys 2000).

Distribution

The general geological, climatic and biogeographical setting of the fauna discussed here is described elsewhere (Humphreys 1999, 2001; Watts & Humphreys 1999, 2000). Dytiscid specimens were collected from five separate calcrete deposits (Table 3): 1, Challa north; 2, Lake Mason north; 3, Depot Springs north; 4, Depot Springs south; and 5, Pinnacles. Site 1 is located in the Austin palaeodrainage that drains towards the Indian Ocean and is part of the upper Murchison catchment lying to the east of Lake Austin. The other sites were from the inland-draining Raeside palaeodrainage that lies to the south of the Carey palaeodrainage, from which it has been entirely separated since at least the

TABLE 2. Physicochemical measurements of water at some dytiscid sites

Date	Conductivity (mS/cm)	Temp (°C)	pH	O_2 (%)	Depth to/of water (m)	Dytiscids present
Friday Well						
28/6/00	5.2	15.1	7.89	39%	2.5/1	*Nirripirti hinzeae* sp. nov. *Nirridessus fridaywellensis* sp. nov.
Salt Well, Lake Mason						
24/6/00	12.3	18	8.00	–	5.5/0.56	*Nirrid. masonensis* sp. nov. *T. raesidensis* sp. nov.
Shearing Quarters Bore, Depot Springs						
26/6/00	6.8	22	7.38	–	1.5/9.5	*Nirrid. fridaywellensis* sp. nov.
Site 425, Depot Springs						
28/6/00	5.5	25	–	–	2.7/10	*Nirrid. fridaywellensis* sp. nov.
Nyung well, Challa Station						
22/6/00	3.9	20.4	7.67	39%	4/2	*Nirrid. challaensis* sp. nov.
Site 432, Pinnacles Station						
28/6/00	11.4	24.5	7.62	–	4.5/36	*Nirrid. pinnaclesensis* sp. nov.

TABLE 3. The distribution of stygal species of dytiscids amongst discrete calcrete bodies (1–12) in the Yilgarn district of Western Australia. The separate palaeodrainage systems (A–C) and the Indian Ocean and interior drainages are indicated. Numbers denote the locations in Fig. 40. Common superscripts 1–6 denote sympatric species

Calcreted body	Genus *Tjirtudessus*	*Nirridessus*	*Kintingka*	*Nirripirti* gen. nov.
A. Western drainage: Austin palaeodrainage				
1 Austin Downs	–	*bigbellensis*	–	–
2 Cue	*magnificus*[2]	*cueensis*[2]	–	–
3 Challa north	–	*challaensis* sp. nov.	–	–
B. Eastern drainage: Carey palaeodrainage				
4 Paroo	*eberhardi*[3]	*pulpa*[3]	*kurutjutu*[3]	–
5 Lake Violet	–	undescribed sp.	–	–
6 NE Lake Way	*hahni*	*morgani*	–	–
7 Hinkler Well	–	*hinkleri*	–	–
8 Mount Windarra	–	*windarraensis*[4] *lapostaae*[4]	–	–
C. Eastern drainage: Raeside palaeodrainage				
9 Lake Mason north	*raesidensis* sp. nov.[5]	*masonensis* sp. nov.[5]	–	–
10 Depot Springs north*	–	*fridaywellensis* sp. nov.	–	–
11 Depot Springs south*	–	*fridaywellensis* sp. nov.[6]	–	*hinzeae* sp. nov.[6]
12 Pinnacles	–	*pinnaclesensis* sp. nov.	–	–

* Depot Springs north and Depot Springs south are separate expressions of calcrete at the surface but are considered to be a continuous calcrete body by the pastoralist (M. Cavallaro, personal communication, 26 June 2000).

Cretaceous (Humphreys 1999 in press), and in which there are many stygal dytiscid taxa (Watts & Humphreys 1999, 2000). The distribution of taxa by calcrete body is shown in Table 3.

As found previously (Watts & Humphreys 1999, 2000), each species is restricted to a single calcrete region (Table 3) and half the sites contain sympatric non-congeneric Dytiscidae. Owing to the sparse sampling of many species, a more detailed sampling of these aquifers would be expected to increase the number of sites containing Dytiscidae, and may show species to be more widely distributed than currently found.

The prediction of a much richer fauna of stygobitic Dytiscidae in Western Australia (Watts and Humphreys 2000) has been fulfilled. Since only about 10% of the major calcrete deposits in the palaeodrainage channels of Western Australia (Humphreys 1999) have been sampled for stygofauna, it is likely that numerous additional subterranean Dytiscidae, as well as other stygobitic taxa, especially Crustacea, remain to be discovered in the northern Yilgarn region.

This paper reaffirms that the dytiscid fauna of the Northern and Eastern Goldfields areas of the Yilgarn is uniquely diverse by world standards. Molecular work has commenced to determine the origins and evolution of this diverse stygofauna.

Acknowledgments

It is a pleasure to acknowledge the assistance of Susan Hinze in the field sampling and sorting; Julianne Waldock for laboratory processing; Rob Gutteridge (Adelaide) for drawing the illustrations. We thank Kevin Morgan and Philip Commander for access to information about bore locations and for unstinting access to their knowledge of the Yilgarn aquifers. Information about the locations of, and access to, sampling sites was kindly provided by many pastoralists in the region.

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AUSTRALIAN ABORIGINAL CULTURES GALLERY 'THE SPEAKING LAND': A REVIEW ARTICLE

J. V. S. MEGAW

MEGAW J .V. S. 2001. Australian Aboriginal Cultures Gallery 'The Speaking Land': a review article. *Records of the South Australian Museum* 34(2): 115–125.

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> [M]useums are representations of the societies in which they are situated...They are repositories of culture, machines for recontextualization, and platforms for the creation and promotion of cultural heritage. (Ames 1992: 47)

It has often occurred to me that the normal manner of reviewing various forms of major public manifestations, be they plays, opera or ballet, at the very beginning of their existence before they have grown into some degree of harmony with what is perceived to be the original intent of their creator(s), is about as meaningless as trying to assess a major new museum project too soon after its public opening.

The new Australian Aboriginal Cultures Gallery at the South Australian Museum is no longer so new. So how are we to offer a critique, now well over a year after that major event in the calendar of cultural innovations along the cultural drag that is Adelaide's North Terrace, the opening of the Gallery by the Premier of South Australia on 3 March 2000? Certainly it seems a far cry from the publication of the Edwards Report with its largely damning comments on the situation as it was then on the North Terrace and its guidelines for future improvement (Edwards 1981: 89–96).

Firstly, it must be remembered that, like all critiques purporting to be objective, this present article is one person's view of a complex whole which itself attempts to reflect varying human reactions to varying environments over more—almost certainly much more—than 50 000 years. Also, given the Museum's laudable and continuing involvement of indigenous Australians—another feature which continues a key recommendation of the Edwards Report — while my comments may reflect contemporary and personal contacts with varying groups and individuals from contemporary indigenous Australian society, I am of course not an indigenous Australian. Perhaps the Anthropology Editor of these *Records* should commission a second article to add an indigenous voice to these whitefella comments – albeit that too would be only one voice among many.

It is no excuse—if excuse is needed—to add that, like practically any outsider who has been accepted into a remote indigenous community, I too have an indigenous name plus all the responsibilities of a whole new group of 'skin' relations. It hardly needs to be emphasised that there is nothing mystical in this system of 'honorary' relationships; it is a purely practical solution to a practical problem, of locating us others within the community. But any outsiders who find themselves in a similar situation and think that they are thereby entering a true state of 'Aboriginality', or that they have passed some form of initiation, are deluding themselves; Bruce Chatwin (1987), among others, has much to answer for.

Secondly, the enormity of the task that the Museum's curatorial and adjunct staff, materially assisted by the project's Sydney-based designers and multimedia consultants, set themselves has been nothing less than ambitious. Philip Jones, who wrote the original brief for the Australian Aboriginal Cultures Gallery (hereafter AACG—the plural in 'Cultures' is significant) but since then seems, enviably, to have moved from the hurly-burly of museum curatorial work to a life of almost uninterrupted research, stated in 1996 that the new gallery would seek

> to present an encyclopaedic view of Aboriginal material culture and traditions which cannot be duplicated elsewhere. The depth of the Museum's artefact and archival collections, together with our commitment to a working partnership, will ensure that result' (quoted in Kean 2001).

Philip Clarke (2001), who really had the overall responsibility for bringing the AACG from concept to reality, has stated the aim rather more succinctly:

> The main aim of the exhibition is to describe the technologies used by Aboriginal people who have lived in the climatically variable continent of Australia for over 50,000 years.

In its attempt to achieve this, the exhibition team has used 3000 of the Museum's total of around 30 000 Aboriginal ethnographic specimens. This is a very impressive proportion, considering that most museums rarely have more than a twentieth of their collections on public display. Until very recently, ethnographical collections have been the Cinderellas of the museum world. Despite a renaissance of interest in material cultural studies (as Reynolds 1989 has noted), there is still a shortfall in staffing, both to curate and to manage collections. Leaving on one side the question of the disadvantages as opposed to the benefits of dividing these often ill-defined duties, Reynolds recorded the results of a survey of museums as sources of information. He commented that in Australia in 1981, the average number of artefacts for which curators in some

FIGURE 1. Level 1, Australian Aboriginal Cultures Gallery, South Australian Museum, showing Dress exhibit with MacDonnell Ranges exhibit at left rear. Photo © South Australian Museum.

nine museums were responsible was around 15 500, with four in his sample exceeding 20 000. At the present time there are two curators responsible for the ethnographic collections of the South Australian Museum and each have well in excess of 20 000 objects under their care.

The excitement of the opening long since over, missing labels placed in position, lighting levels tweaked—but I find them lower than conservation good practice demands—what are the impressions one now has as one turns into the Gallery from the panoramic airiness of the rebuilt main entrance of the Museum? One Saturday morning I followed a small school party of ten-year-olds around. The first reaction was, 'Isn't it dark?' So it mostly is (Figure 1) and while there are clearly good conservation reasons for this, I could see nowhere a visible (!) explanation. This, then, is not a place to experience, save in miniature, the hard light of the desert or the blue of the skies of the Great South Land.

In the AACG both the distant past and the immediate present appear only as rather slender bookends to the central theme. While the relative down-playing of the latter is defensible, particular in the light—literally—of the indigenous 'talking heads', the former, despite what may be gleaned from the touch-screens of the 'Speaking Land', seems little more than a display-in-progress, with precious little space let alone actual material to support the lengthy timeline. The Museum has indeed been too long without the services of a full-time Curator of Archaeology. This is a mere apology for antiquity which crams into a few cubic metres what is labelled with excessive conservatism 50 000 – 60 000 years of indigenous settlement. True, Roger Luebber's fascinating, if still largely unpublished, discoveries in 1973–74 of 10 000-year-old wooden artefacts at Wyrie Swamp in south-east South Australia are featured on the 'Speaking Land'. I looked in vain, however, for any even halfway reasonable treatment of the late Graeme Pretty's excavations, also yet to be fully published, of the burial ground at Roonka Flat on the Murray, a site where archaeology and local indigenous concerns came together in complete harmony.

Nonetheless, the Australian Aboriginal Cultures Gallery has been designed not just for indigenous Australians (though it is clear that without the cooperation of many indigenous Australians there would have been no new gallery) and not just for all Australians, but for all visitors to the Museum, be they from Jogjakarta or Jamaica, Argentina or Aberdeen. So there is another test which needs to be applied: how well does the AACG carry out its overall brief to inform all, whatever be the depth of their ignorance or their lack of interest in the face of more pressing matters, such as the latest modern Disney fairytale or a day at the footy?

There is an enormous plus to this display. Along the north wall of the gallery as one enters Level 1, there is a large panel of portraits selected by Fiona Macdonald. These are mostly monochrome photographs, with Norman Tindale and Unaipon sharing the honours with Pastor Johann Reuter and many others. A few 'windows' offer film clips in colour of smiling faces (an intentional choice to start things on a positive spin?) but there is no sound. For that one has to move on to the eight regional sections where individual voices (literally talking heads) speak to you (the viewer), drawing you in to the display, inviting you to be part of it. Everyone must be attracted to one or other screen, neatly activated when the visitor stops to read the brief descriptive label. For me, Judy Lucas speaking of her return from Adelaide to her family's ancestral land up the Birdsville Track eloquently represents the plight of many that have sought their roots after long separation.

Here is the *Leitmotiv* of the AACG. It is not the static displays which seem to catch the attention of every visitor but, in a neat marriage between new technology and ancient rights and beliefs, the 'Speaking Land', the title which greets you as you sink—oh bliss, oh joy—into the liberally distributed, leather-covered banquettes. Strategically placed, here are the various touch-screen monitors that allow one to self-drive through the various themes, technologies and regions which make up the AACG; '1600 images, 50 video clips, 20 audio clips and 12 virtual reality sequences' trumpeted the media release at the opening.

In parenthesis, while obviously the strengths of the Museum's holdings have determined the content of the 'Speaking Land', the total absence of any coverage of the first significant point of culture contact in the Sydney–Hawkesbury region, let alone demonstration of the same region's rich rock-art, borders on the parochial. Be that as it may, the technology—both the software and hardware, purpose designed and built—certainly works but one wonders for how long and at what cost to maintain. I have not been surprised to observe that most visitors under the age of thirty, early on in their visit, drift toward the screens like so many moths attracted to the light on a dark night.

But this is not to complain; on the contrary. The previous major indigenous ethnographic display at the South Australian Museum was *Ngurunderi: an Aboriginal Dreaming*. This exhibition had much the same curatorial team as for the AACG, followed the admirable policy of indigenous consultation and cooperation, and presented the story of the Lower Murray and the Coorong delta—roughly equivalent to the South-East region in the new display—from prehistory to the present, with an excellent introductory film, mixture of text panels, touch-screens, static displays and, most popular of all, a number of full-scale dioramas. As I observed some years ago (Megaw 1990: 81):

> In preparing some of the three-dimensional exhibits for *Ngurunderi,* despite the long and almost universal popularity of the South Australian Museum's dioramas, the (non-Aboriginal) design team was concerned to get away from the earlier types of presentation of the Aborigine-as-showcase-artefact...In the end it was decided to use no three-dimensional figures at all and to restrict any humans to contemporary illustrations, two dimensional reconstruction drawings or indistinct background figures in a landscape...This was certainly not the wish of several of the Ngarrindjeri advisers as there have been many questions asked by a gratifyingly large number of Aboriginal visitors to the exhibition: 'Where have all the people gone?'

After one's voyage of discovery through the various modules—an unchartered voyage since it seems to have been the curators' and the designers' intent that there should be no set pathway, the wisdom of which I think may be debatable—many visitors who make their way to the second, upper, level of the exhibition, may well feel like the prisoners in the last act of Beethoven's *Fidelio* drawn to the light, in this case the Indigenous Information Centre. But few enter it. The Centre, which contains the archives of the Aboriginal Family History project, is serving a vital role in continuing to make available to indigenous Australians its unrivalled genealogical resources. It seems a pity that more of the general public are not availing themselves of yet another computer-based resource and of the opportunity to speak to indigenous staff, especially to the tour guides, graduates of Tauondi's Cultural Agency (formerly the Aboriginal Community College).

It has to be said that 'art', however you define that elusive little three-letter word, is not foregrounded in the AACG. This may be intentional recontextualisation, to offset the decontextualisation (the 'you-don't-have-to-know-anything-about-art, just-feel-the-quality') approach of the sister institution next door, the Art Gallery of South Australia. Indeed, some of the artistic treasures of the AACG are almost hidden. At the northern end of the second level of the Gallery is the great acrylic painting, a cooperative exposition of four separate 'Dreamings', commissioned by the Museum in 1996 and executed over a three-day period by no less than 29 Warlpiri and Anmatyerre men and women. This cries out for more than the comparatively brief and distinctly dry explanatory panel in order fully to unpick the various 'webs of relatedness', to get something of the flavour—let alone smell—of the context out of which such art arises (for art it is by anyone's standards). I can remember, on my first visit to Papunya 20 years ago, the shock of realising that great art was being produced on the desert floor with the camp dogs lifting their legs on the canvas edges and the painters literally sitting on the canvas, the better to execute their share of the composition.

In the temporary display area on the ground floor there is some attempt to get away from a sanitised approach to art. Currently there is a selection from the 30 doors from the school at Yuendumu painted in 1983 at the invitation of the school principal by senior Warlpiri men, partly as an educational tool and partly as a riposte to their women folk who had already been producing works on canvas for sale (Warlukurlangu Artists 1987). I observed my sample visitor making a bee-line for one of the doors and exclaiming 'Look, Dad, are there any other tags?' and pointing to where—absolutely correctly in my opinion—ArtLab, in undertaking conservation of the doors, had not removed the word 'LIZZIE'.

There is work to be done here on the later associations of, and reactions to, the Yuendumu doors. This material should then be included in the data bank of the 'Speaking Land', though I was delighted to see inclusion of a clip from the Film Australia's film 'Dreamings' made by indigenous film-maker and photographer Michael Riley to accompany the block-buster exhibition of the same name. I looked but did not see evidence of use of the ABC's brilliant film made in 1989 starring Dr Christopher Anderson (Director of the Museum during the AACG's development stage), a work which demonstrated that a little liquid lubrication does wonders for one's fluency in speaking extempore to camera. *Market of Dreams* must surely rank as one of the best visual studies

dealing with aspects of 'ethnographic' art and is worthy to take its place beside Curtis Levy's *Sons of Namatjira*, made for the then Australian Institute of Aboriginal Studies in 1974.

Despite its relative down-playing of contemporary material culture, whether of outback communities or town and city, in many ways it seems to me that the AACG stands up well in comparison to the exhibits in other institutions. One may cite attempts in Melbourne, Canberra and Sydney to make the 'today' as well as the 'yesterday' of indigenous Australia intelligible to a world in which *we* not *they* are the 'other'. By and large, these seem to have succumbed to the tyranny of the designer, liberally assisted by more than a touch of political correctness, not to be confused with sensitivity towards indigenous concerns, a sensitivity which clearly suffuses much of the AACG.

Consider in contrast *Bunjilaka* at the new mega-Museum of Victoria (which sidelines the archaeological perspective—Russell 2000), the 'Gallery of First Australians' in Canberra's National Museum of Australia (which opened in March 2001—for a brief description see: Anon. 2001 and for a less-than-enthusiastic review see

FIGURE 2. Level 2, Australian Aboriginal Cultures Gallery, South Australian Museum, showing Play exhibit, 'The kukuru game'. Photo © South Australian Museum.

Mundine 2001), or the first to redesign its public galleries, the Australian Museum in Sydney. All three demonstrate a clear polemic in favour of a number of contemporary issues, a matter by no means shirked in Adelaide's AACG. While these other new displays rate ten out of ten for presenting 'The Important Issues', they get barely a pass mark for presentation. In Canberra, the individual cases with their heavy stainless steel frames, and small objects often dominated by metal supports, together with the general open-plan design of the Museum, may be summed up in one word—'unsympathetic'. It is a relief to move into the reserve collections and return to the principles of open storage.

After all, there is nothing that dates so quickly as fashions in design. Certainly one can only admire, tinged with envy, the obviously generous publication budget available to the National Museum but, just as in its current displays (which seem at times to be closer to street theatre than to the stereotypical serried ranks of glass museum cases), there are some odd omissions. To produce a catalogue (Taylor 2001), let alone an exhibition, showing concepts of the land as seen through contemporary indigenous art which includes neither the acrylic paintings of the Centre nor Hermannsburg watercolours is taking innovation too far.

Adelaide's AACG is in certain ways a surprisingly old-fashioned display. Examine the division into technological themes (Figure 2) such as boomerangs, spears, glue (vital indeed, since the development of adhesive permitted, for example, the manufacture of multibarbed projectiles), baskets, drugs, stone tools, watercraft (a popular item with younger visitors), string and fire (fire that can destroy and can regenerate life). In view of the fact that Philip Clarke started out his professional life as a biologist, it is no surprise that this taxonomic-cum-evolutionary approach should be to the fore.

Thus the AACG, despite its apparent 'modernity', may be likened to the displays in the South Australian Museum's Pacific Gallery. Further afield, one could point to the older displays at the Pitt Rivers Museum of the University of Oxford, which still reflect the principles of cataloguing and display by type of object (Figure 3) established by the museum's

FIGURE 3. Pitt Rivers Museum, University of Oxford. Henry Balfour working on the weapons displays in the Upper Gallery, c. 1890. Photo: © Pitt Rivers Museum, University of Oxford.

original benefactor, Lieutenant General Augustus Henry Lane Fox Pitt Rivers (1827–1900). He espoused the then new principles of sociocultural evolutionism, or 'applied anthropology' as he called it. In the context of considering under what terms he might leave his collection to the Nation on his death, he declined to make any special stipulations about 'the arrangement of the objects':

> If my system were accepted by men of science, it would be continued. If it were not, there would be no object in continuing it. Moreover, views become so much changed as knowledge accumulates that it would be mischievous to hamper the future with ideas of the present (quoted by Chapman in Cranstone & Seidenberg 1984: 16; see also Bowden 1991: 50–51, Petch 1996).

Thus he expressed his confidence that his system was scientifically objective and would stand the test of time. *Plus ça change . . .*

Classification, as we have already noted, is indeed what museums are about and there are continuing debates as to how to do it, especially in the area of (what it is no longer fashionable to call) 'ethnographic displays'. In a very percipient essay born of the author's experience of the British Museum's Museum of Mankind—currently being returned to its Bloomsbury home—Durrans considers differing approaches to the re-presenting (rather than representing) of cultures undergoing change. 'Museums are increasingly criticized not only for the way they represent certain themes in exhibitions, but also for their choice in the first place' and he adds, 'appreciating the social and cultural setting of an object does not exhaust and is not a substitute for an appreciating of the object itself' (Durrans 1988: esp. pp.155–158; on ethical issues and the use of photo archives see also Pinney 1989).

Michael Ames, the Canadian anthropologist and museologist, has frequently argued for 'empowerment' of those who in the past have so frequently been denied access to the strong rooms of their own material past, our museums. In 1976 Ames introduced in the University of British Columbia's Museum of Anthropology—surely one of the world's most perfectly sited public buildings—his system of visible storage.

> The system operates like a large library or supermarket, with the exception that customers can handle objects only under staff supervision; meanwhile, they have unhindered visual access to collections *and to the catalogue data* (Ames 1992: 91, my emphasis).

And this is the difference. In Adelaide it is fine to have the opportunity not only of regular guided tours but, in particular, the resources of the Indigenous Information Centre. In the displays however, as we have already observed, it is visible information that is really noticeable by its absence, being either difficult to find or to read once found, or simply not there (for example, the 31 shields and the 13 feather decorations on the west wall of Level 2). It seems writ large over every designer's CAD screen 'Thou shall not use one word when you can get away with none'. The AACG's labels, where they exist, are restricted to the briefest of information as to provenance and accession and it has become a truism of museum best practice that one underestimates at one's peril the power of language to marginalise (Coxall 2000).

It is not enough to provide that 21st century equivalent to the fair ground fruit machine – the touch-screen. As recent research into the effect of early introduction to computers on learning skills has shown, it is often detrimental, rather than of assistance, to understanding. On my half-dozen or so visits since the Gallery opened, I have overheard at the Museum Shop requests for 'more on the Aboriginal Gallery' or 'Haven't you got something about the Yuendumu doors?' There is of course, but bilingual texts don't attract your average museum visitor wanting to know more but not *that* much more (see Warlukurlangu Artists 1987). Too many museum institutions underrate the public's desire for portable information, the movable relic, the link with the artefact. It is rare to find in museum visitors' books comments that echo Samuel Goldwyn Jnr's Philistine cry: 'Don't confuse my mind with facts—it's already made up'.

Commencing with the wall of portraits, the still images as well as archival film employed in the displays represent but the tip of another resource iceberg. The danger is that the archival images, like icebergs, can 'sink the ship'. It may well be argued that photography retains a certain immediacy, an assurance of contextual truth and realism which can assist the appreciation of the object better even than three-dimensional reconstructions which, however realistic, remain just that. But the camera captures only an aspect of truth. For one thing, as soon as the photograph has been taken it becomes an historical document (and for some people irrelevant or, worse, mistaken as a representation of the present). Further, we see the subject not through the lens of the camera so much as through the eyes of the

photographer, a particular human being with his or her own cultural inheritance and assumptions. The best that can be hoped for is that the viewer can perceive *what* it was that drew the photographer's attention at that particular place and at that moment in time.

For many people, Baldwin Spencer's pioneering images of the turn of the 20th century, or Tindale's of no more than a generation ago, have become (mere) historic curiosities; they have started to represent just that kind of exotica which is what first attracted museums to collect. David Attenborough, who has done so much to broaden our horizons to encompass much of what has heretofore lain outside our normal ken, is still within the tradition of the exotica hunter.

We are reminded when we look at such technically superb still images as those produced by Charles Mountford or Axel Poignant, or more recently Penny Tweedie, that there is the *aesthetic* intent in photography to consider as well. In a study of a curator from the American Museum of Natural History who collected and photographed in the Congo before World War II, Mirzoeff (1998: 169) notes how the

> photograph is transformed by intimacy from a document into art...Any reading of photography is dogged by the cultural construction of the photograph as either observed truth or transcendent art.

Conscious of this dilemma, the Edwards Report advises:

> Great care must be taken to associate the audio-visual presentation directly with actual objects and displays in the museum, so it is not just an event in its own right, but also an integral part of the museum (Edwards 1981: 90).

Not so much a case of *caveat emptor* as 'beware anthropologists bearing cameras and exhibition teams waving photographs'.

One may add here that something of the same kind of problem of creation and control arises in the recording and subsequent storage of sound. Why is it that the archival voice-overs of the early film used in the AACG sound stilted, foreign, almost exotic in contrast to the immediacy, the 'relevance' of the indigenous talking heads? It is not just a matter of improved recording technology and playback facilities. 'Imagination' and 'political motivation' have been emphasised as being essential in exploiting the immense possibilities of recorded sound in the museum setting (Silver 1988: 194).

Despite the explicit statements of intent already quoted, there is in fact something of a lack of detail in the philosophy behind the AACG. I do not know what sort of comparative research went into planning the AACG. If one were to look for prior guidance, despite the obvious common ancestry in the colonial foundations of our older museums and the best efforts of COMA (the Conference of [Australian] Museum Anthropologists), there has been comparatively little published in Australia on various aspects of museums and material culture, in contrast with the situation overseas. To whole volumes in the field one must add the admirable journal produced by the Museum Ethnographers Group in the United Kingdom, which I have had cause to cite at various points in this review (Barringer & Flynn 1998; Pearce 1989; Shelton 1997; compare Mulvaney 1990).

As to how the punters have reacted to this, the greatest—and, praise be—free show in Adelaide, why in fact they come at all, or why many of them do not first make a bee-line for the fossils and the much overrated Egyptian Room (a protected heritage site not so much because of the Ptolemaic—and frankly hideous—mummies but rather because the room is such a perfect example of museum display techniques c. AD 1940), these are questions to which as yet there are no answers.

According to the Museum, over 850 000 people have come through its doors during the 16 months since its re-opening, but it is not known how many of those visited the AACG, nor is there any information as to age, socioeconomic grouping or ethnicity. We know that there have been around 25 000 school children through the AACG during the same period and several hundred enquiries made at the Indigenous Information Centre; we do not know what sales of specifically indigenous Australian titles there have been at the Museum Shop strategically placed immediately to the left of the main entrance, though I have a shrewd idea that anything to do with dinosaurs would win hands down.

Certainly there is nothing available which is on a par with Merriman's (1989) examination of a decade ago as to the role that museum visiting plays in British culture. The total lack, as yet, of any information about the AACG in general or its component parts, in any language other than English, says little for the Museum's marketing department or its image in a multicultural world—though the Museum Shop sports copies of Wally Caruana's 1993 introduction to indigenous Australian art, in both German and French. Perhaps one needs to consider more the role of

the museum shop in our museums, again something which has been discussed for a number of years in the United Kingdom and elsewhere (White 1996, 2001).

Yet in one of a handful of serious reviews devoted to the AACG, or for that matter to any other display (on this lack see Wehner 2001), John Kean, far from decrying what he terms 'the traditional values of scholarship, the primacy of the collection and the legacy of the institution's own history', concludes that 'the brave mood to run counter to the contemporary museological currents has resulted in an exhibition of sustained power and surprising emotive force' (Kean 2001).

Over all is the image and the voice of Norman Tindale, the butterfly collector turned anthropologist whose position in the annals of indigenous Australian studies has been assured by nearly 50 years of devotion to the life—past, present and future—of Aboriginal society and

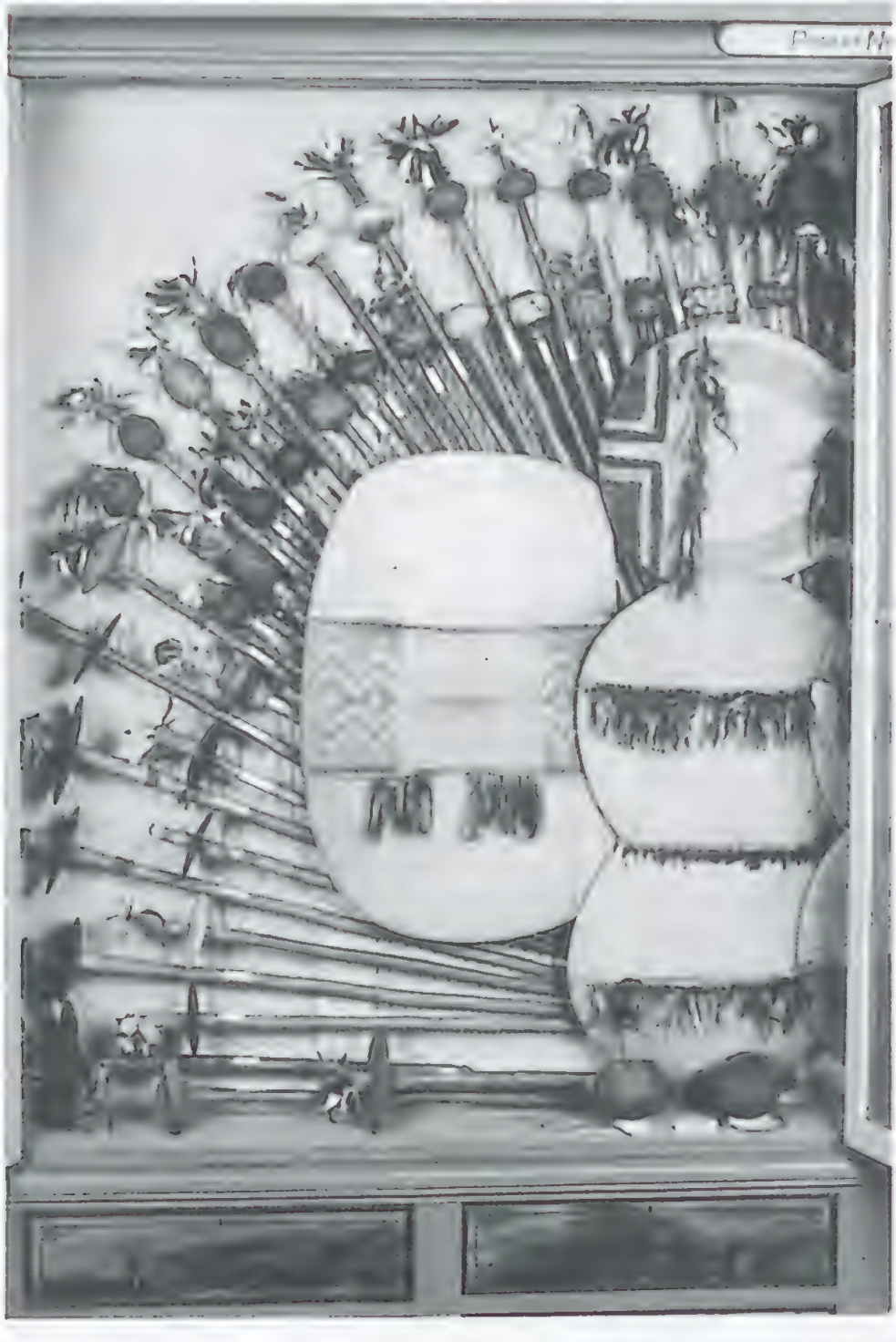

FIGURE 4. South Australian Museum, Pacific Cultures Gallery. Part of display of shields and stone-headed clubs from Central Province, Papua New Guinea. Photo: Barry Craig, 1998.

culture. Tinny's legacy is prodigious but Philip Clarke and his collaborators have produced something of which all who are interested in indigenous culture can be proud. Clarke (2001) is surely right when he comments:

> The future challenge for the South Australian Museum is to maintain the relevance of the material it displays. Given the flexibility of the design and the use of the 'Speaking Land' interactives, it should be possible for future curators to reinvigorate the display without going through a total reinstallation.

Mindful of Pitt Rivers' words quoted above, we should remember that a truly static display is a dead display. By the terms of the definition with which I started this article, the AACG team has done well. While I hope that there will indeed be scope for revision and alteration in the years to follow (especially with regard to the 'bookends'), the Australian Aboriginal Cultures Gallery should remain as a visible example of further movement towards indigenous empowerment together with maintenance of the highest standards of conservation and scientific enquiry—in other words, just what reconciliation should be all about.

A final thought: we have waited a long time for the Australian Aboriginal Cultures Gallery to become a reality. How much longer will we have to wait until the 'foreign' ethnographic collections are given the same makeover? (Figure 4). The disruption to that Gallery caused by the alterations to the buildings in 1999 have not been made good, with at least a third of the exhibits lacking information labels of any kind. And chicken wire has surely had its day as a feature at the cutting edge of display technique.

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ELASMOSAUR (REPTILIA: PLESIOSAURIA) BASICRANIAL REMAINS FROM THE EARLY CRETACEOUS OF QUEENSLAND

BENJAMIN P. KEAR

KEAR, B. P. 2001. Elasmosaur (Reptilia: Plesiosauria) basicranial remains from the Early Cretaceous of Queensland. *Records of the South Australian Museum* 34(2): 127–133.

A near complete basioccipital and associated elements belonging to a juvenile elasmosaur are described from the Early Cretaceous (upper Albian) of northern Queensland. This is the first record of well-preserved elasmosaur basicranial remains from Australia. The basioccipital is comparable to those known from other elasmosaurs but is unusual in the contribution of the exoccipital-opisthotic facet to the margin of the occipital condyle (but not to its articular surface) and dorsal termination of the condylar groove. The significance of this morphology is discussed.

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Examination of juvenile elasmosaur remains (AM F87826) from the Early Cretaceous of Queensland has revealed a previously unrecognised near complete basioccipital. This represents the first record of well-preserved elasmosaur basicranial remains from Australia. The cranial remains of Australian elasmosaurs are extremely rare, being confined to a single badly crushed skull (QM F11050) in which the basicranium is obscured by overlying elements and matrix. This specimen was tentatively attributed to the genus *Woolungasaurus* by Persson (1982); however, Thulborn & Turner (1993) reassigned it to Elasmosauridae indet., following Welles (1962) who considered *Woolungasaurus* a *nomen dubium*. A small tooth-bearing bone interpreted as a plesiosauroid maxilla by Longman (1935) was shown to be an ichthyosaurian premaxillary, maxillary or dentary fragment by Persson (1960). This paper describes the recovered basioccipital and associated elements of AM F87826, and provides a brief character analysis of plesiosaur basioccipital morphology.

Cranial terminology follows Andrews (1910, 1913), Brown (1981) and Cruickshank (1994). Institutional abbreviations: AM, Australian Museum, Sydney; QM, Queensland Museum, Brisbane; UWA, University of Western Australia, Perth. All measurements were taken using callipers and are in millimetres (mm).

SYSTEMATICS

Class REPTILIA

Subclass SAUROPTERYGIA Owen, 1860

Order PLESIOSAURIA de Blainville, 1835

Superfamily PLESIOSAUROIDEA (Gray, 1825) Welles, 1943

Family ELASMOSAURIDAE Cope, 1869

Elasmosauridae genus and species indet.

Material

AM F87826, a partial neck and base of skull including the basioccipital, at least 33 cervical centra, parts of the neural arches, several partial cervical ribs and miscellaneous fragments. Lack of fusion between basicranial elements and associated vertebral centra, neural arches and cervical ribs indicates that the specimen is a juvenile.

Locality

'Dunraven' Station, near Hughenden, central-northern Queensland. Toolebuc Formation, upper Albian (Day 1969; Smart & Senior 1980).

Diagnosis

Basioccipital condyle with a squared dorsal margin and heart-shaped condylar outline. Exoccipital-opisthotic facets of the basioccipital contribute to the occipital condyle margin but do not form part of the condylar surface. Groove circumscribing the basioccipital condyle terminates dorsally at the posterolateral edges of the exoccipital-opisthotic facets. Cervical centra platycoelous with articular surfaces having an open V-shaped cross-section and margins which form an abrupt angle with the centrum sides. Length of the anterior cervical centra is greater than their height. Lateral surfaces of cervical centra bear distinct longitudinal ridges.

Description

Basioccipital. (Fig. 1, Table 1).

The basioccipital has suffered damage to the left pterygoid facet but is otherwise well preserved. The anterior basioccipital surface is dominated by a prominent, deeply rugose facet for contact with the basisphenoid. This is dorsoventrally compressed and reniform in outline, extending partly onto the anteroventral surface of the basioccipital. The dorsal-most facet margin is produced into a narrow transverse ridge, which borders the posteriorly inclined anterodorsal surface. This bears a prominent circular depression with median pit probably representing part of the posterior wall of the pituitary fossa or dorsum sellae (Cruickshank 1994). Chattergee & Small (1989)

TABLE 1. Measurements (mm) of basioccipital AM F87826, * – not including missing pterygoid facet portion

Description	mm
Total length	29.3
Total width*	34.9
Width across exoccipital-opisthotic facets	24.4
Condyle diameter	19.8

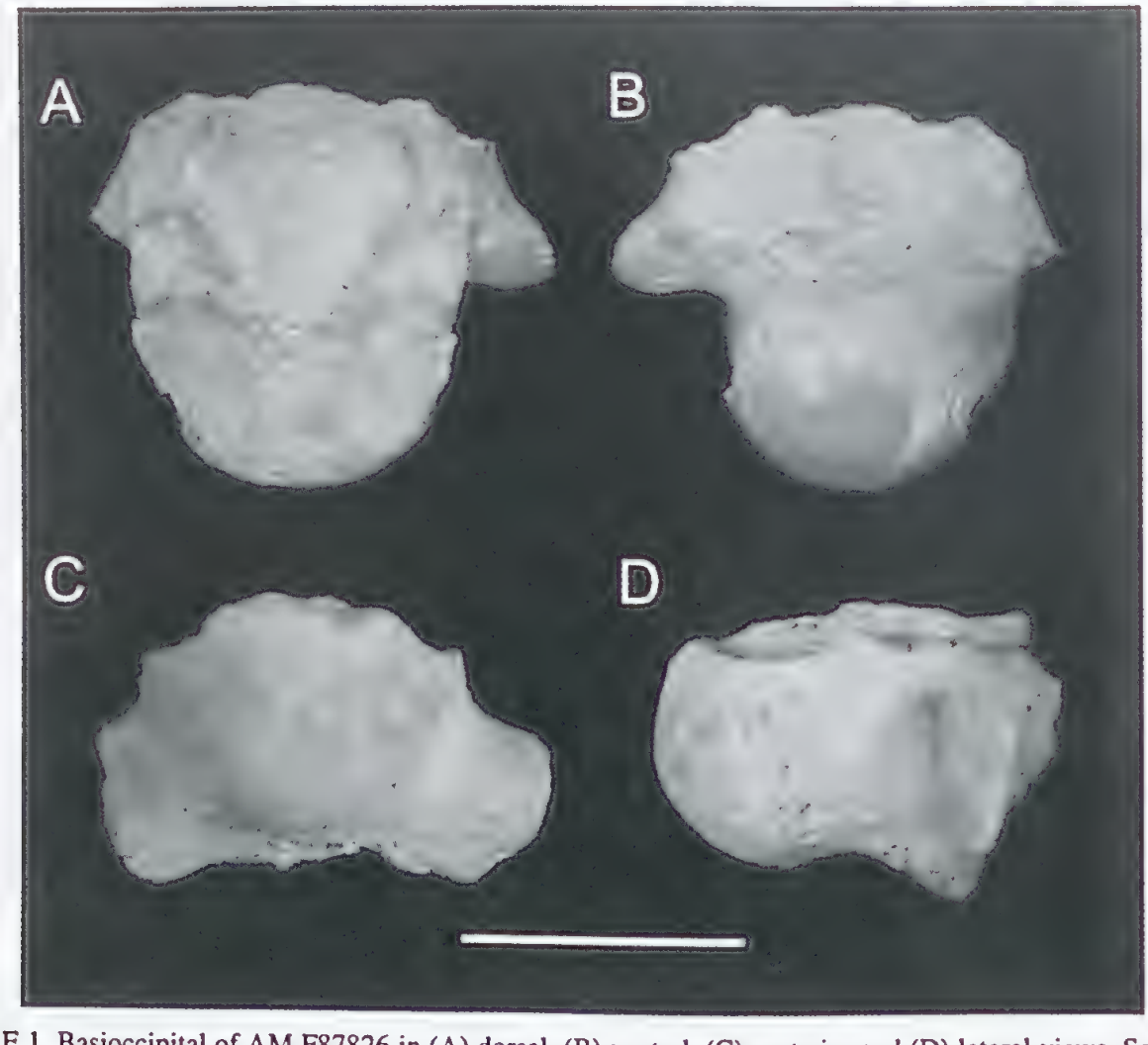

FIGURE 1. Basioccipital of AM F87826 in (A) dorsal, (B) ventral, (C) posterior and (D) lateral views. Scale bar is 20 mm.

interpreted a similar pit in the basioccipital of *Morturneria* (from the Maastrichtian of Antarctica) as representing the 'hypophyseal-basicrania' fenestra. The anterodorsal circular depression is medially subdivided by a shallow vertical groove and bordered laterally by deep longitudinal channels. These extend posteriorly onto the rugose dorsal surface. The dorsal surface of the basioccipital bears a pair of broad ovoid facets for the exoccipital-opisthotic elements, which form part of the condylar margin but do not contribute to the articular surface (comprised entirely of the basioccipital). Between the exoccipital-opisthotic facets is the spindle-shaped floor of the endocranial cavity. Anteriorly, this expands into a raised triangular plateau, which bears a shallow longitudinal depression (extending to a notch in the anterodorsal margin of the dorsum sellae) possibly representing the sella turcica (see Welles & Bump 1949). Anteriorly, the exoccipital-opisthotic facets are separated from the small circular prootic facets by low transverse ridges. The anterior prootic facet margin is raised and irregular suggesting the presence of cartilage, possibly supporting a forward expansion of the prootic onto the basisphenoid. The anterolateral basioccipital surfaces are produced into short, massive pterygoid processes, which terminate in anterolaterally oriented, triangular pterygoid facets. The pterygoid facet surfaces are smooth and separated anteromedially from the rugose basisphenoid facet by a prominent vertical flange. The basioccipital condyle is rounded, lacks a notochordal pit and is weakly heart-shaped in outline, with the squared dorsal margin forming the edge of the foramen magnum. The condylar surface is partly circumscribed by a shallow groove which terminates dorsally at the posterolateral edges of the exoccipital-opisthotic facets.

Axial skeleton. (Fig. 2, Table 2).

At least 33 complete to fragmentary cervical vertebrae have been recovered, representing portions of the anterior (Figs 2A, 2B), middle (Figs 2C, 2D) and posterior (Figs 2E, 2F) cervical series. Fragmentary remains of the neural arches and some cervical ribs are also preserved. The anterior cervical centra are cylindrical and somewhat dorsoventrally compressed with centrum length always exceeding the height. This trend is lost in the middle and posterior cervical series where the centrum width exceeds the length. There is a marked increase in overall size of the cervical centra from the anterior to posterior section of the neck.

The articular surfaces of the centra are platycoelous, smooth and ovoid in outline, becoming near elliptical posteriorly. In transverse cross-section, the articular surfaces of all centra are an open V-shape, with the margins of the face forming an abrupt angle with the centrum sides. A small notochordal pit shallowly indents the centre of each articular surface. Dorsally, each centrum bears a prominent median hourglass-shaped

TABLE 2. Measurements (mm) of AM F87826 vertebral centra. Numbering of centra begins at the anterior-most and does not include the atlas or axis. A gap including an unknown number of centra is present between C27 and C28. * – centrum represented only by fragments

Element	Length	Width	Height
C1	24.9	22.2	17.7
C2	26.4	22.9	19.1
C3*	–	–	–
C4	–	–	21.5
C5	–	–	28.1
C6	39.4	–	26.4
C7	42.9	–	29.4
C8	–	33.5	22.2
C9*	–	–	31.1
C10	49.8	–	33.9
C11	61.3	–	–
C12*	–	–	–
C13	–	–	52.4
C14	63.6	–	–
C15	62.7	70.8	49.8
C16	67.4	–	50
C17	65.1	74.7	53.9
C18	64.8	73.9	53.1
C19	–	75.6	–
C20	65.2	74.5	54.3
C21	67.1	–	55.9
C22	66.8	78.7	56.4
C23	67.8	78.5	56
C24	66.7	80.1	–
C25	67.7	78.3	56.8
C26	66.7	79.3	–
C27	61.6	91.3	58.9
C28*	–	–	–
C29*	–	–	–
C30	54.2	85.2	50.2
C31	–	80.6	–
C32	44.2	90.6	60.4
C33	57.4	93.1	61.2

depression marking the neural canal. In the anterior-most vertebra, this becomes transversely narrow towards the anterior margin of the centrum where the depression is bordered laterally by the large ovoid facets for the neural arches. The neural arch facets are deeply concave and situated close to the anterior margin, becoming more centrally placed and extending to the edges of both the anterior and posterior articular facet rims in successive centra. The neural arch facets are separated ventrally from the elliptical cervical rib facets by the deeply concave lateral centrum surface. The lateral surface of each centrum bears a distinct longitudinal ridge. The rib facets are raised, deeply concave and situated close to the posterior articular rim. The ventral surface of each anterior centrum is markedly concave and bears paired nutrient foramina separated by a broad median-ventral keel. The nutrient foramina become progressively more laterally placed in successive vertebra with a corresponding reduction in prominence of the mid-ventral keel.

The neural arches are fragmentary but preserve parts of the neural arch body and neural spines. The neural arches possess thin lateral walls enclosing the neural canal, and deeply excavated anterior surfaces. The anterior excavation is tall and elliptical in outline with a narrow median

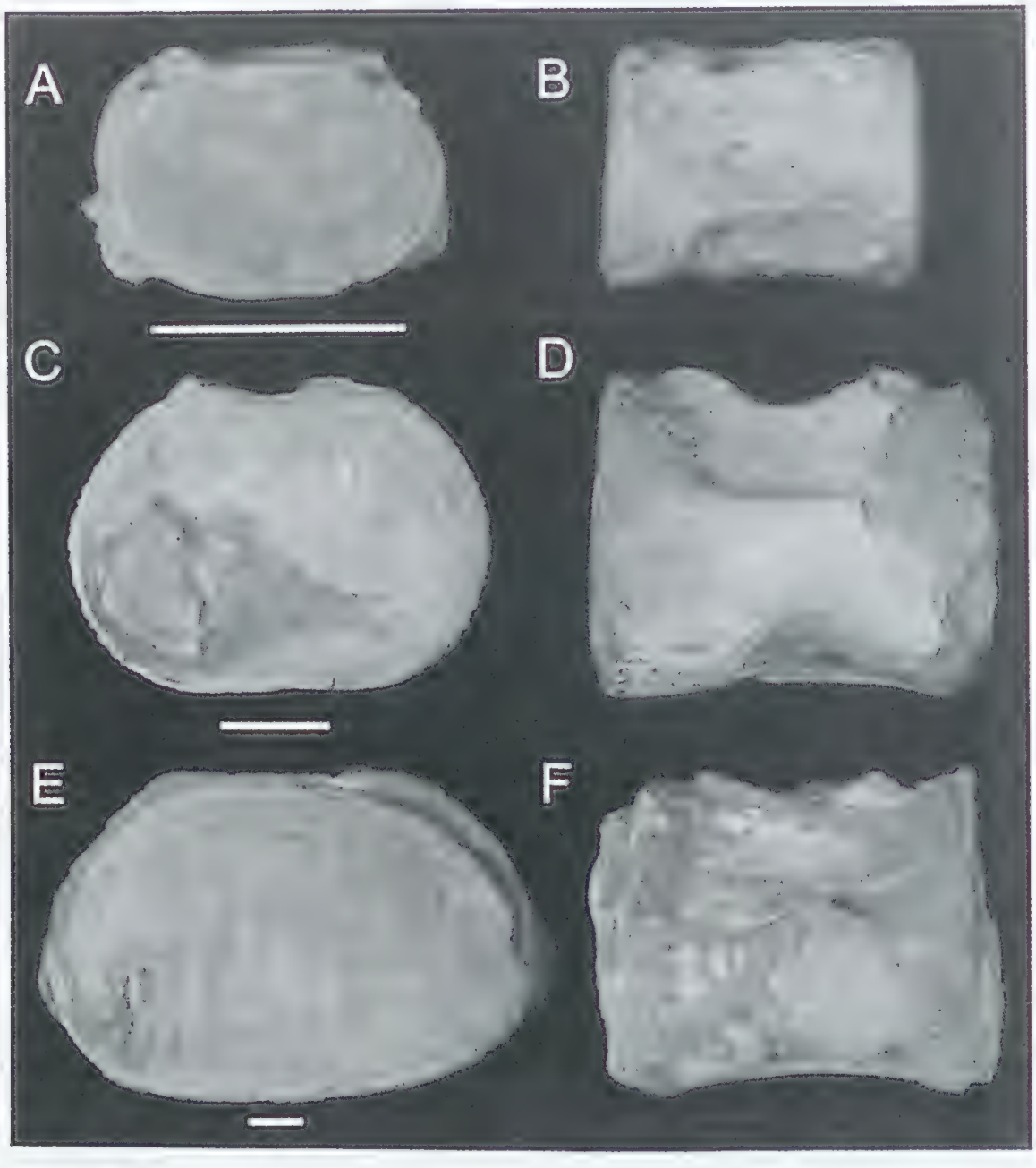

FIGURE 2. AM F87826 anterior (C2) cervical centrum in (A) anterior and (B) lateral views; middle (C15) cervical centrum in (C) anterior and (D) lateral views; and posterior (C27) cervical centrum in (E) anterior and (F) lateral views. Scale bars are 20 mm.

vertical septum. The neural spine fragments are strongly transversely compressed and elliptical in cross-section.

All recovered cervical ribs are fragmentary and lack unequivocal associations with the centra. The cervical ribs are all single headed with anteroposteriorly elongate and ovoid articular facets. The articular facet surface is concave and finely pitted with slightly flared flange-like margins. The rib shafts are dorsoventrally compressed and elliptical in cross-section.

Remarks

AM F87826 is comparable in its vertebral morphology to Cretaceous elasmosaurid material from elsewhere in Australia (eg Persson 1960, 1982; Murray 1987), particularly isolated remains from unspecified (probably Albian) deposits near Oodnadatta (Freytag 1964), and the Neales River region (SAM P6181, Persson 1960), South Australia; and the Late Cretaceous (Cenomanian–Turonian) Molecap Greensand, Western Australia (UWA 22034, Long & Cruickshank 1998). All of these specimens exhibit proportionately short posterior cervical centra.

AM F87826 can be assigned to Elasmosauridae indet. on the basis of: (1) platycoelous articular surfaces on the cervical centra. The presence of platycoelous articular surfaces is considered an elasmosaurid synapomorphy by Brown (1981, 1993) and Bardet et al. (1999). The character-state is also known to occur in the Maastrichtian cryptoclidid *Morturneria* (Chattergee & Small 1989), however this taxon has more recently been reinterpreted as a derived elasmosaurid (Bardet et al. 1991); (2) articular surfaces of cervical centra with open V-shaped cross-section and margins which form an abrupt angle with the centrum sides. This is an apomorphic state potentially uniting all members of the Elasmosauridae (Brown 1993; Bardet et al. 1999) and can be distinguished from the plesiomorphic condition in cryptoclidids and plesiosaurids, in which the articular surfaces are sigmoidal in cross-section with a raised convex rim (Brown et al. 1986; Brown 1993); (3) anterior cervical centra with length greater than their height. The presence of anterior cervical centra which are elongate relative to their height is an unequivocal synapomorphy of all elasmosaurids (Welles 1952; Brown 1993; Bardet et al. 1999); (4) lateral longitudinal ridges on the cervical centra. Prominent longitudinal ridges are present on the lateral surfaces of the cervical centra in all elasmosaurids, representing a potential synapomorphy for the group (Welles 1943, 1952, 1962; Brown 1993; Bardet et al. 1999). Brown (1981), however, noted that the feature is variable with ontogeny, being less well developed in younger individuals.

Comparisons And Discussion

AM F87826 is comparable in its basioccipital morphology to other elasmosaurs, particularly *Libonectes* which also exhibits a squared dorsal condylar margin and heart-shaped condylar outline (Carpenter 1997). The specimen is unusual, however, in the exoccipital-opisthotic facets participating in the condylar margin, and subsequent dorsal termination of the condylar groove. This differs from the common condition in elasmosaurs, and most other plesiosauroids, in which the condylar groove completely circumscribes the occipital condyle, excluding it from contact with the exoccipital-opisthotic facets (Welles 1962; Brown 1981; Bardet *et al.* 1999). Exclusion of the exoccipital-opisthotic facets from the condylar rim is also known to occur in nothosaurids (Rieppel 1994). A character-state similar to that of AM F87826 is present in the Rhaetian/Hettangian taxon *Thalassiodracon* (Storrs & Taylor 1996) and the Maastrichtian *Morturneria* (Chattergee & Small 1989). Such comparable morphology may be the result of convergence in the case of *Thalassiodracon* (as suggested by the presence of the plesiomorphic condition in nothosaurids and most plesiosauroids including elasmosaurids); however, the recent reclassification of *Morturneria* as a derived elasmosaurid (Bardet et al. 1991) does raise the possibility of homology. Distinct condyle–facet contact is also known to occur in *Cryptoclidus* (Andrews 1910; Brown 1981), *Kimmerosaurus* (Brown 1981), *Eurycleidus* (Cruickshank 1994) and pliosaurids (Andrews 1913) but involves contribution of the exoccipital-opisthotic to the basioccipital articular surface and absence of a distinct condylar groove. AM F87826 can therefore be interpreted as autapomorphic in its condylar morphology.

Incomplete dorsal closure of the condylar groove may, alternatively, represent an ontogenetic feature similar to the variable groove development present in juvenile specimens of *Muraenosaurus* (Brown 1981). Complete separation of the exoccipital-opisthotic facets and occipital condyle in all growth stages of *Muraenosaurus* (Brown 1981), however, supports interpretation of the facet–condyle contact in AM F87826 as a potentially apomorphic character state.

Molnar (1991) suggested that Australian plesiosaur faunas lacked extensive regional endemism and were composed of largely cosmopolitan forms. While this is almost certainly true for higher taxonomic categories, the presence of potentially autapomorphic elasmosaur remains suggests that at least some distinct taxa may have inhabited the Australian epicontinental seaway and surrounding coastal regions of eastern Gondwana during the Early Cretaceous.

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WARRABARNA KAURNA! RECLAIMING AN AUSTRALIAN LANGUAGE.

Rob Amery. 2000. Multilingualism and Linguistic Diversity Series 1. Swets & Zeitlinger Publishers, Lisse, The Netherlands. 290 pp. Reviewed by Philip A. Clarke.

For many indigenous communities living in former European colonies, cultural change occurs on several fronts, such as with language loss, cessation of religious practices, decline in artefact and art traditions, the movement away from key places in the landscape, and the loss of biological distinctiveness through intermarriage and population decline. And yet, even for parts of the world where all of this has to a large degree occurred, the descendants of some pre-European indigenous groups remain today with some level of group identity.

In *Warrabarna Kaurna!*, Rob Amery provides a cultural history of the Kaurna Aboriginal community, whose members are the descendants of indigenous people living on the Adelaide Plains before British settlement began here in 1836. Chapters 1–3 provide a background to the linguistic literature on language reclamation, including non-Australian examples. The following two chapters, 4–5, provide a history of the Kaurna people and how their language and traditions were recorded by Europeans. The next five chapters, 6–10, deal with the Kaurna language reclamation attempts and their significance to the re-emerging Adelaide Aboriginal identity. Chapter 11 is the summary and conclusion. The book is richly endowed with maps, plates, graphs and tables.

Amery has had extensive experience with researching and teaching Aboriginal languages. He has been involved in a number of workshops on Aboriginal language reclamation and since 1997 has run the Kaurna Language and Language Ecology course at Adelaide University. Although the impact of language loss occurs widely to varying degrees across Aboriginal Australia, Amery has based his study in an area where the local Aboriginal groups have suffered much.

In the 'settled regions', generations of Aboriginal people were largely absorbed into the European community due to economic and social pressures or, until the mid 1960s, given a broader identity as marginalised Aboriginal people living as wards of the state. Starting in the late 1970s, many of their descendants have reclaimed their identity, marking a period of cultural revitalisation (Berndt 1977, Keen 1988). The descendants of the Aboriginal hunters and gatherers who lived on the Adelaide Plains are one such group, referring to themselves as Kaurna people. Similar revivals have occurred elsewhere in the world, in particular North America (Clifford 1988). How much of this contemporary culture is due to an unbroken connection with the past, or to what degree it relies on an identity largely regained through external sources such as historical records and museum artefact collections, is debatable.

Warrabarna Kaurna! is a study of the rebuilding of a particular Aboriginal cultural identity, once considered vanished forever. Although Amery is deeply sympathetic towards the aspirations of contemporary Aboriginal people in being recognised as having a valid cultural identity, he nevertheless acknowledges the complex interplay of sources which produce the modern beliefs and perceptions of the Kaurna community. Amery brings Aboriginal cultural revitalisation into focus by studying an attempt by Aboriginal and non-Aboriginal agencies to reclaim an Aboriginal language.

When Europeans arrived in Australia, there were many Aboriginal languages. Estimates by linguists range from 150 to 650, depending on how one defines 'language' (Blake 1981, Yallop 1982). These indigenous languages are today threatened as more and more Aboriginal people adopt Aboriginal Pidgin English and creoles (Kriol) as their primary means of communicating (Wurm et al 1996). Many languages have vanished entirely. In temperate regions, where British settlement was most concentrated, the forms of speech used by Aboriginal people today approach standard Australian English. Amery concedes that the chances for a complete reversal of this process are slim. Despite this, he recognises that the study of indigenous languages has broad cultural importance, rather than being merely of linguistic interest. As stated in the foreword by Lester-Irabinna Rigney, a Kaurna descendant, 'the languages of colonised peoples cannot be meaningfully discussed outside the context of imperialism, colonialism and neocolonialism'.

It is in the context of the contemporary significance of the Kaurna language that Amery enters the debate about the use of terms such as

'extinct', 'dead' and 'sleeping' for forms of speech that have largely survived through recordings made by Europeans in the 19th century. *Warrabarna Kaurna!*, which means 'Let Kaurna be spoken', is about using the Kaurna language to gain an insight into the pre-European indigenous culture and extending its use into a modern cultural context. Amery places the 'ownership' of the language in the hands of Aboriginal people who have identified genealogical links with the pre-European landscape of the Adelaide region, although he acknowledges that its development from the 1990s springs from a collaboration with non-indigenous people, such as linguists.

The Aboriginal culture of the Adelaide Plains has been elusive for many authors, partly due to the early demise of the local Aboriginal population with the onset of European settlement and through the impact of other Aboriginal cultural groups with whom the Adelaide people merged during the historic period (Clarke 1991a). By the early 20th century, the Curator of Ethnology at the South Australian Museum, Norman Tindale, was able to locate only a few Aboriginal people who were knowledgeable of what he considered as the 'traditional' pre-European culture of the region (Tindale 1974: 60–61, 213; Tindale & Mountford 1936: 500–501; Tindale & Pretty 1980).

Based upon his research, and with the aid of the now outdated 'tribe' theory, Tindale introduced and promoted the use of 'Kaurna' to describe the cultural group encountered by German missionaries, such as Christian Teichelmann and Clamor Schürmann. He used 'Kaurna' despite the fact that the Aboriginal informants of Teichelmann and Schürmann used different terms for themselves that were based upon smaller territorial units (Clarke 1991b). Although the exact origin of the term 'Kaurna' is in question, with some suggestion that it is based on the Lower Murray word *korna*, for 'man', it is nevertheless a useful word when referring to the pre-European Adelaide inhabitants. *Warrabarna Kaurna!*, which is the published form of Amery's much larger PhD thesis, provides a compendium of everything currently known to have been written about the early Aboriginal culture of the Adelaide Plains as it was encountered by the first Europeans to settle in South Australia.

Contrary to popular opinion in Australia today, Aboriginal people in pre-European times did not have a collective consciousness of being 'Aboriginal', or even a term covering this notion. Instead, there were numerous descent groups and language communities that in certain situations may have been defined in opposition to corresponding groups. Upon European invasion, the nature of group identity was radically altered. For instance, in the pre-European period it is likely that the Adelaide people would have been too culturally divergent from the Lower Murray people to be considered as having a sense of identity with them. Nevertheless, after British colonisation, many Aboriginal groups that were formerly distant, both socially and geographically, were placed in contexts where joint identity became possible or was even enforced by the welfare authorities.

As the Australian Aboriginal landscape was transformed to make agriculture possible, many Aboriginal people were removed to missions, such as Point McLeay in the Lower Murray and Point Pearce on Yorke Peninsula, or lived on pastoral properties and government stations. The population of the missions in southern South Australia was made up of Aboriginal people from northern South Australia, West Coast, Eyre Peninsula, Yorke Peninsula, Mid North, Adelaide, Murray Basin, Lower South-East and possibly even Tasmania.[1] Since breaking from their hunting and gathering past and becoming part of a rural landscape, southern Aboriginal people have primarily drawn their identity from their 'mission' homes (such as Koonibba, Point Pearce and Point McLeay), rather than from their pre-European background. Based on the shared elements of their history, these regional identities merge when southern Aboriginal people refer to themselves as 'Nungas' (pronounced 'Narngars').

By the 1980s, when several Aboriginal individuals living in Adelaide began to embrace Kaurna identity, most Aboriginal people in southern South Australia had links to several areas across the State. Amery (2000:8) states 'For many older Kaurna people, their primary identity remains Narungga [Yorke Peninsula] or Ngarrindjeri [Lower Murray], depending on whether they grew up at Bukkiyana [Point Pearce] or Raukkan [Point McLeay], respectively. For others, especially young people

[1] In addition to Amery's work, these regional links can be discerned from the work of Taplin (1859–79), Tindale (1938–39, 1952–54) and Clarke (1994, chapter 2).

who have grown up in Adelaide, Kaurna identity is all-important.'

Kaurna culture is comprised of elements formulated during the last two decades, with the emergent form being part of a new cultural environment. This new identity is focused on pre-European traditions, but has strong urban, rather than mission, influences. Amery provides an excellent account of the sociopolitical activities that have increased and refined awareness of Kaurna culture. Its revitalisation can be seen with the Kaurna song-writing project in 1990, and since this time by Aboriginal dignitaries using Kaurna vocabulary at official openings of cultural events.

The tension between variable anthropological records and equally variable contemporary Aboriginal perceptions is evident at several points through *Warrabarna Kaurna!*. For instance, the Tjilbruke Dreaming of the extended Adelaide landscape was recorded by several European writers, with most of the accounts in their unpublished form relating to a 'blue crane' ancestor, probably a brolga (Amery 2000: 101–102; Clarke 1991a: 66–68). Nevertheless, the most detailed published version, by Tindale, stated that Tjilbruke (Tjirbruki in Tindale) was a glossy ibis (Tindale 1987; Tindale & Mountford 1936). It is this account which has had the most influence with the contemporary Kaurna community and appears in modern renditions of this Dreaming (Education Department of South Australia 1989: 95–101, 213, 217).

For many readers, a less obvious example of the discrepancy between written and oral histories concerns the Aboriginal traditions of the Pleiades, often referred to as the 'Seven Sisters'. After describing the widespread distribution of such beliefs, including from the Adelaide region, Amery (2000: 103) states that 'Versions still survive amongst some Ngarrindjeri women, having been handed down orally from one generation to the next.' I dispute this statement on the basis of historical and ethnographic work done during the 1980s–90s.

Since the political struggles of the early 1990s, some Aboriginal people with Ngarrindjeri connections have become intensely interested in the 'Seven Sisters'. From my fieldwork experience, the versions of 'Seven Sisters' Dreaming accounts being told by Ngarrindjeri women in the early 1990s were said by them to have come either entirely, or at least in part, from Western Desert people. This is supported by the literature. In the 19th century, the historical accounts of the Pleiades point to such elements of the Dreaming mythology as a group of men smoking and turkey eggs, although the records of Aboriginal beliefs about the cosmos are scant (Wells 1852–1855: 99).[2] Ngarrindjeri records of the early and mid 20th century do contain some references to the Pleiades that bear some similarity to the 'Seven Sisters', for example the six girls and one boy of the Yatuka, although they are not stated as siblings (Berndt & Berndt 1993: 163–164; Clarke 1997: 136; Kimber 1997: 229–231). There is also the account of the 'Seven stars' (no identity given) associated with climate (Rankine 1969 cited in Clarke 1994: 123). Nevertheless, these are shallow similarities, so we should be cautious of inferring continuity of belief.

Since European settlement, such widespread mythologies, as in the case of the Pleiades, are learnt not just from local Aboriginal sources, but also from other Aboriginal groups and from the media, as well as from the popular and academic literature. Opportunities for the transmission of ideas are provided by the post-European movements of Aboriginal people, the intermarriage between groups on missions and the engagement of Aboriginal people in broader Australian culture. I would argue that the Pleiades traditions of the 1990s are an example of what some anthropologists have termed the 'invention of tradition' (Hobsbawm & Ranger 1983). New embellishments gain force from contemporary sociopolitical situations, often imparting greater significance to the parent beliefs. Nevertheless, the processes that make them important will often obscure the origin of beliefs. Given that Aboriginal people have not lived in a cultural vacuum since European settlement, and that their culture has not been static but has changed in major ways, there are often other explanations to the evolution of contemporary beliefs that do not necessarily involve transmission through family lines. Studies of contemporary indigenous culture will continue to struggle with the issue of where to draw that blurred line between cultural continuity and transformation.

Warrabarna Kaurna! is well written and illustrated. It provides a useful guide to ethnographic sources on the Kaurna people of the Adelaide Plains. The book also has wider

[2] See Giles in the *Adelaide Register* newspaper, 5 October 1887.

significance, beyond the Adelaide landscape, giving important insights into the sociopolitical environment in which the modern study and use of indigenous languages is carried on. One of the aims of the Multilingualism and Linguistic Diversity series in which it is published is the development of and respect for linguistic human rights. Amery's work rates highly in both regards.

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Records of the South Australian Museum 34(2): 135–138.

OBITUARY

JUNE MAVIS SCRYMGOUR

1920—2000

June Scrymgour was employed by the South Australian Museum for almost 20 years. She achieved Curatorship of Minerals before retiring in 1982, and continued in an Honorary capacity for many more years. She died on 23 September 2000, after a long period of worsening illness.

June was born in Adelaide on 9 June 1920, the first of three children. Rheumatic fever as a child left her susceptible to strokes late in life. She did not complete high school, but left to work as a short-hand typist in the family hardware business. During World War II June joined the Australian Broadcasting Commission (ABC), and for a time became a radio announcer. After the war, she had several secretarial jobs, but with increasing dissatisfaction because of a frustrated interest in natural history.

In 1963 June applied for and obtained a position in the South Australian Museum, as assistant to the newly-arrived Curator of Geology, Dr David Corbett. Despite her lack of formal training in earth sciences, or even natural history, June threw herself wholeheartedly into the task, making notes of any comments by visiting researchers that were pertinent to specimens they were examining. In this way she built up a basic knowledge of the subject, insofar as it was represented in the collections. Subsequently, June found a love of conveying this information to the general public. A number of sets of minerals or fossils typical of different groups or ages were compiled and mounted in book-file boxes for transport to and display at talks she would give to various organisations and groups. At about this time she undertook night school classes and completed her high school matriculation. This enabled her to apply to do the Geology I course at Adelaide University, which she undertook with enthusiasm.

As Corbett had become involved as a lecturer in the Adelaide University's Department of Adult Education, so did June begin to help in the preparation of exhibits for the talks. From 1966 she started to participate, as children's tutor, in the annual Spring Schools organised by that department, the first being to Chowilla on the River Murray. Subsequent venues included Angorichina in the Flinders Ranges (1967), Muloorina near Lake Eyre (1971) and Nonning in the Gawler Ranges (1973). There were also weekend schools for children and Junior Field Naturalists trips in the Adelaide area.

In 1968, following the resignation of David Corbett, the Geology Department of the Museum was split into the Mineralogy and Palaeontology Sections, and a mineralogist, Geoff Milne, was appointed. June continued as assistant to both sections and, although the collections were already basically separated, she set about making the final separation—that of the sectional libraries—and preparing for the arrival of the new curators of each section. Milne arrived in November 1968 and relations with his assistant deteriorated, partly due to different attitudes to the mineral collections and June's natural protective feeling towards the specimens. The arrival of the new Curator of Fossils, Neville Pledge, in mid-1969 alleviated the situation slightly, as June now had a different focus of attention. When, in mid-1970, Milne suddenly resigned and Pledge was away on extended fieldwork, June was again in charge of both sections. On Pledge's return June was given responsibility, in the interim, of the Mineral Section, and subsequently it was decided not to seek a new Curator. With this new responsibility, June undertook an active acquisition program to increase the size, diversity and quality of the mineral collection, mainly by exchange, but she also undertook modest collecting trips around the State in later years. She took a special interest in meteorites and australites, the Museum collections of which had been catalogued by Corbett. Much of her time in later years would be spent with these objects.

In 1967, during the last months of Corbett's curatorship, when June was starting the physical separation of the collections, she began to research the origins of the Museum's collection of Lake Callabonna *Diprotodon* fossils which, with other things, occupied a number of large cupboards in the passage outside the Palaeontology room. As a result, she made contact with a number of descendants of Ragless, Stirling, and Zietz, who had been involved in the 1892–93 discovery and excavation of the bones. She was able to obtain copies of photographs and letters,

and started compiling them with newspaper and other archival reports pertinent to the story she hoped to write. Unfortunately, she was not able to do this. However, the information was not lost but used in an exhibition, and an article published by this writer (Pledge 1994), to celebrate the centenary of the Lake Callabonna expedition.

During this same period June started another project which had a more tangible outcome for her. Partly as a result of leading a South Australian Field Naturalists excursion to see the geology at Hallett Cove, she commenced active field research of the area for the preparation of a field guide. Working with two Museum Honoraries, botanist Margaret Kenny and archaeologist Harold Cooper, she edited and published 'Hallett Cove, a field guide' in 1970, at a time when interest in preserving more of that area was growing. A revised edition was published two years later as a result of the publicity gained for the Reserve in the midst of an encroaching suburban sprawl, and a third printing in 1976. Among other outcomes of the first edition were the discovery of the first fossils (other than the Pliocene shells of the Hallett Cove Sandstone) to be found at Hallett Cove—a much-abraded tooth of the Pleistocene *Diprotodon* found by two schoolboys in beach gravel, and arthropod trails preserved in the Permian glacial varves, found by schoolgirl Helen Bailey during one of the field days at the height of the conservation campaign. Helen had previously been tutored by June on one of the Spring Schools.

Other projects at this time were the production of an illustrated 'The geological timescale (and) evolution—from the rock record' (1973a), for students and the lay public, and co-authoring with David Corbett a chapter on geology in *Yorke Peninsula, a Natural History* (1973b). June was now realising a growing interest in and concern for geological type localities, those sites from which geologists had described new geological features or formations and rock units. This subject would increasingly occupy her time.

With the resignation of Dr Helene Laws, the Curator of Marine Invertebrata, in 1973, June became the mother figure for female staff, a role that sometimes put her in disagreement with management or other curators. However, out of this came some benefit in the form of a new assistant, Faye Gommers, to be shared between Minerals and Fossils, which enabled June to revise the catalogue of meteorites and start other projects. June was now attracting a small but dedicated coterie of volunteers (Mesdames Bertie Koch, Natalie Worthley and Eugenie Pugh, and Mr Gerhard Hörr) and Honorary Research Workers (Messrs Jim Johnson, Barrie Risely and William Cleverly). With the help of many of them, June started compiling a register of geological type sections in South Australia, this information to be used in assessing the environmental impact of proposed mining and exploration activities.

The Geological Data Retrieval System, as it was called, came to occupy more and more of June's time and the Sectional resources as she obtained detailed maps and aerial photographs, and made field trips to various parts of the State to verify and document important geological localities. However, with Jim Johnson, she was also able to produce a popular illustrated booklet on the minerals of South Australia (1975, revised 1978), and with Cleverly (1978) the first of several papers on australites. With Johnson and others she co-authored a description of the Brachina Meteorite (1977), and this led her to start lobbying for legislation to protect meteorites found in South Australia from exploitation by (mostly foreign) commercial collectors. This legislation was passed in 1980, as an amendment to the *South Australian Museum Act, 1976–1978, Part IIA—Meteorites.*

The next few years were busy, with the consolidation of the Geological Data Retrieval System, fieldwork to check sites and search for australites and meteorites, and, from 1979, the requirements and designing of new quarters for the Section in the planned new science wing just approved by the Government. In this last, June was able to increase and improve substantially the collection storage space, laboratories and offices over what they had been in the basement of the old Museum east (Stirling) wing.

Because of her lack of formal academic qualifications, June's achievements were not officially recognised for some years but, after continued lobbying and support from other staff, she was made an acting Curator in 1976 and Curator Grade I in the following year. June was promoted to Curator II in 1981 and retired on 29 June 1982, with planning still in progress for the new science building. On retirement, she was put in charge of the Geoscience Data Centre, and supervised its installation as a separate entity in the new Natural Science Building in 1985. With the appointment of a new Curator of Minerals in 1984, June was appointed an honorary research associate in Mineralogy.

Retirement did not change June's activities

much. Although arthritis prevented her from coming into the Museum regularly, she continued to maintain and upgrade the geological data system with the help of Barrie Risely. Together, they compiled all this information and eventually published it as a book (1991). But this was not the end, although a series of mild strokes were beginning to take their toll. June had, for many years, envisaged a revision of her Geological Time Scale and Evolution chart, and to this end she had accumulated much data from colleagues and other experts. However, the field of palaeontology is, in many ways, changing very rapidly, with new discoveries that change our understanding of evolution almost a weekly event. The task proved, therefore, to be more than she could handle, even by proxy with Risely and Hörr finding and bringing references to her at home, where she had by then become housebound.

June moved in with her younger sister Molly at Brighton in 1995. When Molly died she moved into a retirement home at Aberfoyle Park, and later a nursing home, just days before her death on 23 September 2000. Her last project was unfinished. June never married. She is survived by her brother Peter, and two nieces and a nephew and their families.

June was, within her limitations which she recognised, an outstanding custodian of the collections under her care, meticulous almost to the point of obsession. She engaged well with the public, particularly children, to the advantage of the South Australian Museum for almost 20 years, and was the author or co-author of a number of publications of lasting value.

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(a) title plus an abridged title for use as a running head; the title should include the higher classification of the group being studied in the case of zoological papers
(b) author's/authors' name(s)
(c) abstract (not to exceed 2% of the total length of the paper), followed by author's/authors' postal address(es)
(d) main text
(e) acknowledgments
(f) references.

If footnotes are included they should be kept to a minimum.

4. Conventions

Only papers in English will be considered. The metric (SI) system of units should be used. Spelling should follow the most recent edition of *The Macquarie Dictionary*. Only those words to appear in italics should be underlined.

In taxonomic papers the short form of citation (taxon author, date: page) should be used in listings and in synonymies. Where new species are described the location of the type material should be indicated. Descriptions and listings should be brief as possible. Relevant recommendations of the *International Code of Zoological Nomenclature* should be followed.

Capital letters should not be used in common names of animals except when referring to the first letter of a proper name, eg Wilson's storm-petrel, Australian raven.

For further guidance on style and conventions, authors should consult the most recent (sixth) edition of the *Style Manual for Authors, Editors and Printers*, John Wiley & Sons Australia, Ltd: Brisbane.

5. References

References to literature should be cited in the text using the author–date system, eg (Jones 1985a, 1985b, 1987; Smith et al 1980). If the page number is specified it should appear after the date, eg (Jones 1987: 290).

From 1991 onwards, titles of scientific journals in the list of references will not be abbreviated, but written out in full. The following examples show the method of reference citation:

Journal article–

TINDALE, NB. 1957. Culture succession in south-eastern Australia from late Pleistocene to the present. *Records of the South Australian Museum* **13**(2): 1–49.

Chapter or section of book–

TYLER, MJ, WATSON, GF & MARTIN, AA. 1981. The Amphibia: diversity and distribution. *In* A Keast (ed). 'Ecological Biogeography of Australia', vol. 2, pp. 1275–1301. W. Junk: The Hague.

Book–

MOULDS, MS. 1990. 'Australian Cicadas'. New South Wales University Press: Kensington.

If more than one reference by the same author(s) in one year is cited, these should be distinguished by adding 'a', 'b' etc after the date. Papers which are in press should be included in the reference list.

6. Tables

Tables should be numbered consecutively. They should include a concise, self-explanatory heading at the top. The approximate position in which tables are to appear should be noted on the typescript. Tables must not be larger than A4 in size.

7. Figures

Figures (line drawings, graphs, maps and half-tones or photographs) should be submitted either as originals mounted on white card; as high quality, high contrast photographic prints or bromides; or as original or scanned digital images. Good quality photocopies are generally acceptable. Manual line drawings, maps and graphs should be prepared using black ink on white art paper, thin white card or polyester drafting film. Felt pens and tracing paper should not be used.

Related diagrams or prints should be grouped together to form a single figure and mounted on white card. Each figure should be designed to fit a published width of either 68 mm or 140 mm, and a maximum depth of 205 mm. If figures are larger than this size, they should be photographically reduced and three photographic prints supplied at the size at which they will be printed. Authors should ensure that figures which are to be reduced in size are prepared with sufficiently bold lines and large lettering to accommodate reduction without loss of detail or readability.

Distinguishing numbers or letters must be placed on figures using one of the following fonts: Helvetica, Geneva or Folio. Each figure should be labelled on the back with the author's name and figure number, and an arrow indicating the top. This labelling should be done lightly in pencil or by means of adhesive labels.

Captions for figures should be typed together on a separate page following the References.

The approximate position in which each figure is to appear in the text should be noted on the typescript.

8. Proofs

Authors will receive page proofs for checking. These should be returned as promptly as possible, together with an order for reprints which may be required. Only essential corrections to proofs will be accepted.

NEW SPECIES AND NEW RECORDS OF *CLOACINA* VON LINSTOW, 1898 (NEMATODA: STRONGYLOIDEA) PARASITIC IN MACROPODID MARSUPIALS FROM PAPUA NEW GUINEA

I. BEVERIDGE

BEVERIDGE, I. 2002. New species and new records of *Cloacina* von Linstow, 1898 (Nematoda: Strongyloidea) parasitic in macropodid marsupials from Papua New Guinea. *Records of the South Australian Museum* **35**(1): 1–32.

New species described from macropodid marsupials in Papua New Guinea are : *Cloacina cretheis* sp. nov. from tree kangaroos, *Dendrolagus inustus* (type host), *D. dorianus*, *D. goodfellowi*, *D. matschiei* and *D. scottae*; *C. cunctabunda* sp. nov. from *D. mbaiso*; *C. eurynome* sp. nov. from *D. dorianus* and *D. scottae*; *C. hecale* sp. nov. from *D. dorianus*; *C. theope* sp. nov. from *D. matschiei* and *D. dorianus*; *C. erigone* sp. nov., *C. hyperaea* sp. nov., *C. nephele* sp. nov., *C. polymena* sp. nov., *C. praxithea* sp. nov. and *C. procris* sp. nov. from the scrub wallaby, *Dorcopsis hageni*, and *C. oweni* n. sp. and *C. papuensis* n. sp. from the agile wallaby, *Macropus agilis*. New host records are: *C. caballeroi* Mawson, 1977, *C. sterope* Beveridge & Speare, 1999 and *C. syphax* Beveridge & Speare, 1999 in *Do. hageni*. Additional geographical records are given for *C. cornuta* in *M. agilis*. A key to the known species of *Cloacina* in Papua New Guinea is provided.

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Species of the nematode genus *Cloacina* von Linstow, 1898 occur exclusively in the stomachs of macropodid marsupials. Currently, 103 species are recognised as valid (Beveridge 1998, 1999; Beveridge and Speare 1999) although substantial numbers of species remain to be described (Beveridge 1998). Most of the species described to date are from Australian kangaroos and wallabies, with relatively few records from Papua New Guinea. This situation reflects the paucity of knowledge of the parasite fauna of macropodids from Papua New Guinea, which is based currently on a small number of incidental collections. Nevertheless, material currently available from various kangaroos and wallabies consists of a number of novel species of *Cloacina*. Thirteen new species are described in the current paper as well as new host and distribution records. The opportunity is taken to provide a summary of species of *Cloacina* known from Papua New Guinea together with a key to facilitate their identification. Finally, a preliminary comparison is made between the Australian and Papua New Guinean species and their host distributions.

Beveridge (1998) noted the occurrence of a number of species of *Cloacina* in Papua New Guinea, specifically *C. australis* (Yorke & Maplestone, 1926) in the agile wallaby, *Macropus agilis* (Gould, 1842); *C. caballeroi* Mawson, 1977 in the grey scrub wallaby, *Dorcopsis luctuosa* (D'Albertis, 1874) and the brown scrub wallaby, *D. muelleri* (Schlegel, 1866); *C cloelia* Beveridge, 1998 in the pademelons *Thylogale calabyi* Flannery, 1992 and *T. stigmatica* (Gould, 1860); *C. cornuta* (Davey & Wood, 1938) in *M. agilis*; *C. cybele* Beveridge, 1998 in *T. stigmatica;* and *C. dahli* von Linstow, 1898 in *Thylogale browni* Ramsay, 1877, *T. calabyi* and *T. stigmatica*. Subsequently, based on an examination of the parasites of four small scrub wallabies, *Dorcopsulus vanheurni* (Thomas, 1922), Beveridge & Speare (1999) described seven new species, *C. sancus*, *C. sciron*, *C. sappho*, *C. solon*, *C. solymus*, *C. sterope* and *C. syphax*. Beveridge (1998) noted the presence of undescribed species from the white-striped scrub wallaby, *Dorcopsis hageni* Heller, 1897 in the collections of the South Australian Museum, Adelaide, and from *Do. luctuosa* in the collections of The Natural History Museum, London. Flannery et al. (1996) also reported species of the genus *Cloacina* in a variety of tree kangaroos: *Dendrolagus inustus* Mueller, 1840; *D. goodfellowi* Thomas, 1908; *D. dorianus* Ramsay, 1883; *D. scottae* Flannery & Seri, 1990; and *D. mbaiso* Flannery, Boeadi & Szalay, 1995, a group of kangaroos not previously known to harbour *Cloacina*. These various undescribed collections form the basis of the current report.

Materials And Methods

Nematodes were examined from collections held in the Australian Helminthological Collection (AHC), South Australian Museum (SAM), Adelaide, the Natural History Museum (BMNH), London and the United States National Parasite Collection (USNPC), Beltsville, Maryland. Nematodes were washed in water and cleared in lactophenol. Drawings were made using a drawing tube attached to an Olympus BH2 microscope. Drawings of apical views of the heads of nematodes are oriented with the dorsal aspect uppermost; drawings of the bursa have the ventral surface uppermost. All drawings are of paratype specimens. Measurements were made with an ocular micrometer. All measurements are in millimetres and are presented as the range followed by the mean in parentheses.

Morphological terminology follows Beveridge (1998). Because of the relative uniformity of the genus *Cloacina*, the descriptions presented are abbreviated and follow the format used by Beveridge (1998), in which a full description of the genus was followed by individual species descriptions concentrating on features of diagnostic significance. A detailed description of the genus is available in Beveridge (1998). Features which are relatively invariable, such as the disposition of ventral and lateral bursal rays, are not included in descriptions but are, nonetheless, illustrated.

Types of the new species have been deposited in SAM, BMNH and USNPC. Host nomenclature follows Flannery (1995) and Flannery et al. (1995).

Following previous practice (Beveridge 1998), the names of new species are based on those of classical deities since Cloacina was the Roman goddess of the toilet. An invocational quatrain on this subject, usually attributed to Byron (see Lewin 1999, p. 31), occurs in a number of variations, but the rendering by Lewin (1999) is presented here:

> O Cloacina, goddess of this place,
> Look on thy suppliants with smiling face,
> Soft yet cohesive let their offerings flow,
> Not rashly swift nor insolently slow.

Systematics

Cloacina caballeroi Mawson, 1977

Material examined: 7♂, 13♀, from stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May 1987, SAM AHC 31425.

Remarks

Cloacina caballeroi was described by Mawson (1977) and Beveridge (1998) from *Dorcopsis muelleri* and *Do. luctuosa* from Irian Jaya and Papua New Guinea. This represents the first record from *Do. hageni*.

Cloacina cornuta (Davey & Wood, 1938)

Material examined: 2♂, 1♀, from stomach of *Macropus agilis*, Bula Plain, Bensbach, Papua New Guinea, coll. I. Owen, May, 1998, BMNH 1998.9.28.24–26.

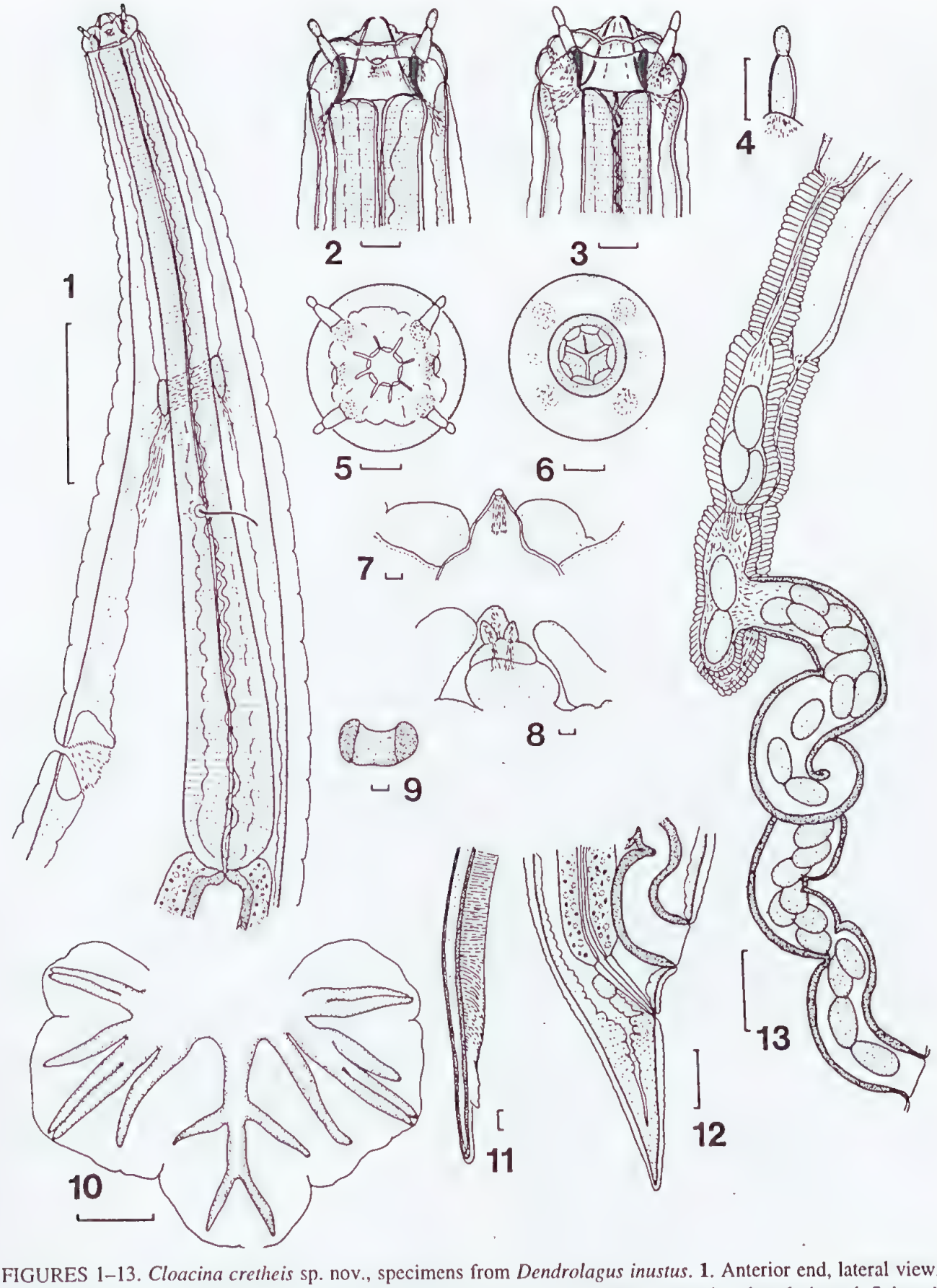
Remarks

Cloacina cornuta was reported from *Macropus agilis* from Port Moresby and Cape Rodney by Beveridge (1998). The present record adds an additional locality. Data provided by Dr I. Owen indicate that in four wallabies examined, numbers of *C. cornuta* ranged from 1650–9600 (mean 4700). Although based on a very small number of wallabies, these data contrast strikingly with those of Speare et al. (1983) for *M. agilis* from northern Australia in which *C. cornuta* was found in only 41% of hosts examined, and with Beveridge et al. (1998) who found the nematode in 35% of wallabies in Queensland. In Australia, *C. cornuta* invariably occurs in much lower numbers than the synhospitalic species *C. australis* (unpublished observations).

Cloacina cretheis sp. nov.
(Figs 1–13)

Types: From stomach of *Dendrolagus inustus*, Mt Somoro, Sandaun Province, Papua New Guinea, coll. T. Flannery, 10.iii.1990. Holotype ♂, SAM AHC 31426; allotype ♀, SAM AHC 31427. Paratypes: 12♂, 12♀, SAM AHC 31428; 1♂, 1♀, BMNH 2001.4.10.1–2; 1♂, 1♀, USNPC 91133. Slide preparations of male, apical views of mouth and bursa, SAM AHC 28378.

Material examined: From *Dendrolagus inustus*: types. From *Dendrolagus dorianus*: 1♂, 4♀, Gunung Ki, Tembagapura, Irian Jaya, coll. T. Flannery, 19.v.1994, SAM AHC 31430; 2♂, 10♀, Lake Trist, Papua New Guinea, coll. I. Redmond, BMNH, 1979, 4486–4505. From *Dendrolagus*



FIGURES 1–13. *Cloacina cretheis* sp. nov., specimens from *Dendrolagus inustus*. **1.** Anterior end, lateral view. **2.** Cephalic extremity, lateral view, dorsal aspect on right-hand side. **3.** Cephalic extremity, dorsal view. **4.** Submedian cephalic papilla. **5.** Cephalic extremity, apical view. **6.** Cephalic extremity, transverse optical section through buccal capsule. **7.** Genital cone, ventral view. **8.** Genital cone, dorsal view. **9.** Gubernaculum, ventral view. **10.** Bursa, apical view. **11.** Distal tip of spicule, lateral view. **12.** Female tail, lateral view. **13.** Female genital system, lateral view. Scale bars: 1, 10, 12, 13, 0.1 mm; 2–9, 11, 0.01 mm.

goodfellowi: 5♂, 5♀, Mt Machold, Sandaun Province, Papua New Guinea, coll. T. Flannery and K. Vula, 13.xii.1990, SAM AHC 31431. From *Dendrolagus matschiei* Forster & Rothschild, 1907: 26♂, 28♀, Huon Peninsula, Papua New Guinea, coll. J. Mayer, July 1999, USNPC 91146. From *Dendrolagus scottae*: 9♂, 5♀, Sweipini, Sandaun Province, Papua New Guinea, coll. T. Flannery, 15.vi.1991, SAM AHC 31429.

Description

Small nematodes; cervical cuticle very slightly inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.030 apart. Submedian cephalic papillae prominent, 0.015 long, projecting anteriorly from peri-oral cuticle; distal segment sub-spherical, 0.005 long, shorter than cylindrical proximal segment, 0.010 long. Buccal capsule shallow, symmetrical in dorsal and lateral views, circular in transverse section, wider than deep, wall without striations. Leaf crown elements 8 in number, slightly recurved at tips; peri-oral cuticle not inflated into lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus slender, claviform, slightly wider at posterior end; lining without sclerotised bosses; denticles absent. Nerve ring in mid-oesophageal region; deirids posterior to nerve ring; excretory pore at level of oesophago-intestinal junction.

Male. Measurements of 5 specimens, types. Total length 6.7–9.0 (7.8); maximum width 0.35–0.45 (0.40); buccal capsule 0.010 (0.010) x 0.023–0.025 (0.023); oesophagus 0.46–0.57 (0.52); nerve ring to anterior end 0.20–0.24 (0.22); excretory pore to anterior end 0.39–0.48 (0.45); deirid to anterior end 0.28–0.36 (0.32); spicules 2.34–2.62 (2.54); gubernaculum 0.03 (0.03) long.

Measurements of 5 specimens from *D. goodfellowi*: total length 7.9–9.3 (8.8); maximum width 0.48–0.56 (0.51); buccal capsule 0.010–0.012 (0.011) x 0.023–0.025 (0.023); oesophagus 0.53–0.64 (0.59); nerve ring to anterior end 0.23–0.24 (0.24); excretory pore to anterior end 0.44–0.53 (0.47); deirid to anterior end 0.20–0.34 (0.29); spicules 2.53–2.94 (2.74); gubernaculum 0.030–0.040 (0.034) long.

Measurements of 3 specimens from *D. scottae*: total length 6.9–9.7 (8.4); maximum width 0.43–0.47 (0.45); buccal capsule 0.010 (0.010) x 0.023–0.025 (0.023); oesophagus 0.48–0.62 (0.56); nerve ring to anterior end 0.20; excretory pore to anterior end 0.40–0.46 (0.42); deirid to anterior end 0.25–0.31 (0.28); spicules 2.63–2.66 (2.65); gubernaculum 0.030–0.035 (0.032) long.

Measurements of single specimens from *D. dorianus:* total length 9.4 ; maximum width 0.43; buccal capsule 0.010 x 0.025 ; oesophagus 0.50 ; excretory pore to anterior end 0.50; deirid to anterior end 0.26; spicules 2.97; gubernaculum 0.035 long.

Dorsal ray elongate; external branchlets arise at 1/3 length, before major bifurcation; angle of bifurcation acute; external branchlets as long as internals, directed postero-laterally, not reaching margin of bursa; internal branchlets originate 2/3 along dorsal ray, directed postero-laterally, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, wider than long. Spicule tip blunt; ala terminates anterior to spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 5 specimens, types. Total length 7.7–9.0 (8.2); maximum width 0.52–0.54 (0.52); buccal capsule 0.008–0.010 (0.010) x 0.023–0.025 (0.023); oesophagus 0.48–0.55 (0.53); nerve ring to anterior end 0.20–0.30 (0.23); excretory pore to anterior end 0.39–0.50 (0.44); deirid to anterior end 0.26–0.33 (0.30); tail 0.23–0.31 (0.27); vulva to posterior end 0.35–0.40 (0.38); vagina 0.50–0.73 (0.62); egg 0.075–0.080 (0.080) x 0.040–0.050 (0.045).

Measurements of 5 specimens from *D. scottae*: total length 8.8–10.7 (10.0); maximum width 0.49–0.64 (0.59); buccal capsule 0.008–0.010 (0.009) x 0.020–0.025 (0.023); oesophagus 0.53–0.58 (0.55); nerve ring to anterior end 0.20; excretory pore to anterior end 0.48–0.50 (0.49); deirid to anterior end 0.29–0.32 (0.30); tail 0.23–0.32 (0.28); vulva to posterior end 0.38–0.40 (0.39); vagina 0.53–0.58 (0.56).

Measurements of 3 specimens from *D. dorianus*: total length 8.8–9.2 (9.0); maximum width 0.49–0.72 (0.60); buccal capsule 0.010–0.013 (0.012) x 0.023–0.025 (0.024); oesophagus 0.53–0.60 (0.57); nerve ring to anterior end 0.23 (0.23); excretory pore to anterior end 0.48–0.51 (0.49); deirid to anterior end 0.20–0.29 (0.24); tail 0.21–0.25 (0.23); vulva to posterior end 0.49–0.50 (0.49); vagina 0.64–0.67 (0.66); egg 0.070–0.075 (0.078) x 0.040–0.050 (0.045).

Female tail short, conical; vagina elongate, convoluted; egg ellipsoidal.

Remarks

C. cretheis sp. nov. is characterised by submedian papillae with a small sub-spherical distal segment, a simple buccal capsule, eight elements to the leaf crown, a slender, unornamented oesophagus, deirids posterior to the nerve ring, a dorsal ray in which the external branchlets arise before the major bifurcation and an elongate, convoluted vagina. The shape of the dorsal ray alone separates it from all congeners except *C. caballeroi*, *C. enyo* Beveridge, 1998, *C. ips* Beveridge, 1998, and *C. syphax*. It differs from all of these except *C. caballeroi* in having the deirid posterior to the nerve ring, although in some highly contracted specimens of *C. cretheis*, in which the anterior oesophagus becomes sinuous, the deirid may appear more anteriorly on the contracted cuticle. *C. cretheis* is further distinguished from *C. syphax* which has a sinuous anterior margin to its buccal capsule and submedian cephalic papillae with enlarged distal segments. *C. cretheis* is distinguished from *C. caballeroi* by spicule lengths, which are 2.34–2.97 mm in *C. cretheis* compared with 1.23–1.45 mm in *C. caballeroi*. The spicules of *C. enyo* are 0.68–0.88 mm long while those of *C. ips* are 1.36–1.39 mm in length, providing a further means of distinguishing the latter species.

C. cretheis occurs in a wide range of tree kangaroo species in Papua New Guinea and was by far the most frequently encountered species in tree kangaroos in this study. It does not occur in either *Dendrolagus bennettianus* DeVis, 1887 or *D. lumholtzi* Collett, 1884 in Australia (Spratt et al. 1991). Although incomplete, the measurements of specimens from different hosts suggest that there are no major differences induced by the host species. Some of the minor differences observed are due to the state of contraction or of preservation of specimens, and the incomplete sets of measurements reflect the poor state of preservation of many of the specimens, precluding the measurement of internal organs.

Cloacina cunctabunda sp. nov.
(Figs 14–23)

Types: From stomach of *Dendrolagus mbaiso*, Camp Ridge, Tembagapura, Irian Jaya, coll. T. Flannery, 24.v.1994. Holotype ♂, SAM AHC 31432; allotype ♀, SAM AHC 31433. Paratype ♂, 3 slides, SAM AHC 28379.

Description

Small nematodes; cervical cuticle slightly inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.015 apart. Submedian cephalic papillae prominent, 0.010 long, projecting anteriorly from peri-oral cuticle; distal segment ovoid, 0.006 long, longer than cylindrical proximal segment, 0.004 long. Buccal capsule shallow, symmetrical in dorsal and lateral views, oval in transverse section, slightly deeper dorso-ventrally, wider than deep, wall without striations. Leaf crown elements 6 in number, recurved at tips; peri-oral cuticle, inflated; inflations not attached to each element of leaf crown. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus slender, claviform, slightly wider at posterior end; lining without sclerotised bosses; denticles absent. Nerve ring in mid-oesophageal region; deirids anterior to nerve ring, mid-way between nerve ring and buccal capsule; excretory pore anterior to level of oesophago-intestinal junction.

Male. Measurements of holotype and paratype. Total length 3.30, 3.32; maximum width 0.16, 0.17; buccal capsule 0.008, 0.010 x 0.025, 0.025; oesophagus 0.34, 0.35; nerve ring to anterior end 0.16, 0.18; excretory pore to anterior end 0.26, 0.30; deirid to anterior end 0.11, 0.14; spicules 1.39, 1.57; gubernaculum 0.015, 0.015 long.

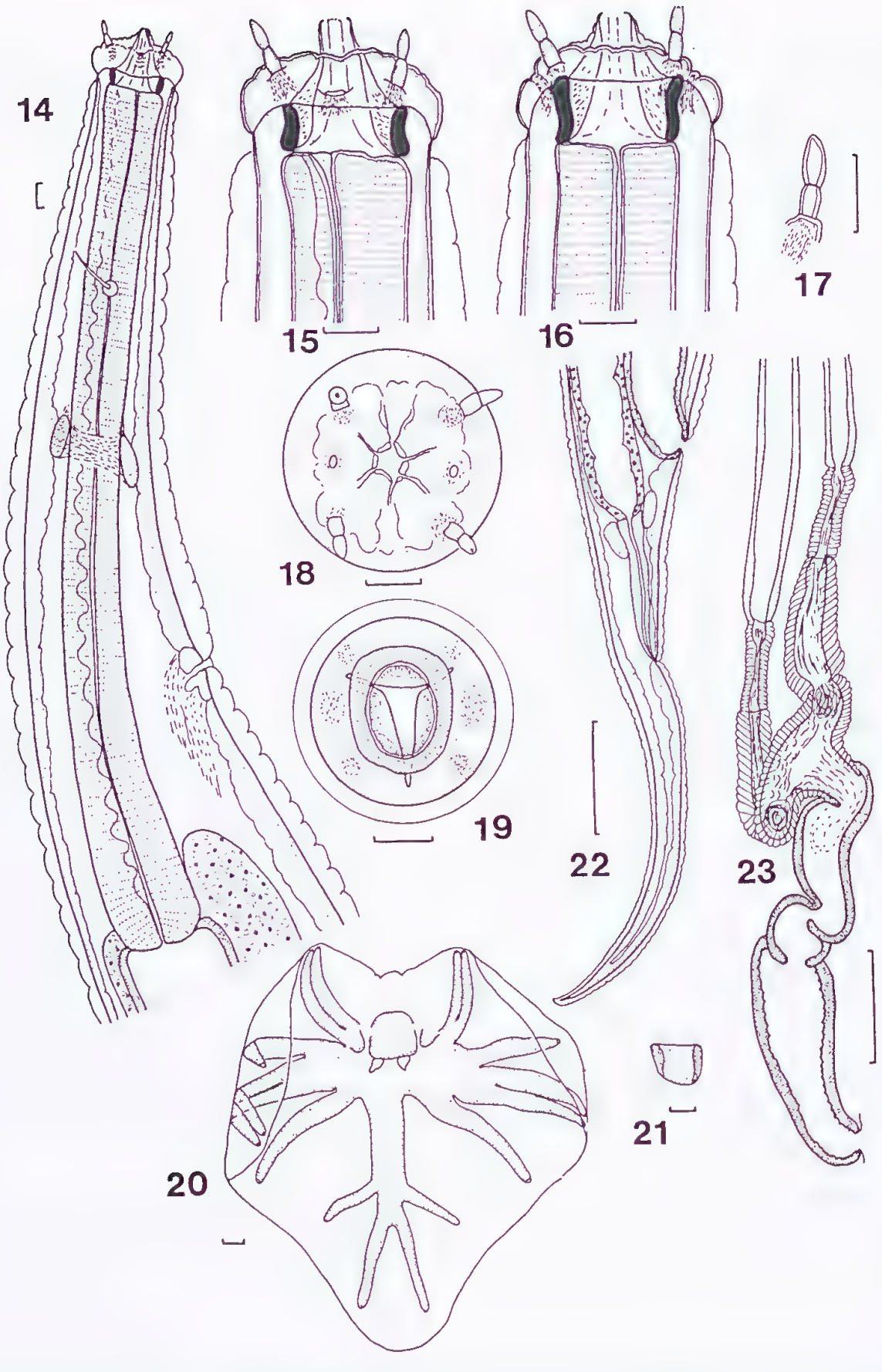
Dorsal lobe of bursa and dorsal ray elongate, ray broad at origin; external branchlets arise at 1/2 length, immediately before major bifurcation; angle of bifurcation acute; external branchlets shorter than internals, directed postero-laterally, not reaching margin of bursa; internal branchlets originate soon after externals arise from dorsal ray, directed postero-laterally, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, wider than long. Spicule tip not everted. Anterior lip of genital cone conical; posterior lip with paired projections.

Female. Measurements of allotype. Total length 4.25; maximum width 0.21; buccal capsule 0.010 x 0.025; oesophagus 0.40; nerve ring to anterior end 0.18; excretory pore to anterior end 0.29; deirid to anterior end 0.11; tail 0.35; vulva to posterior end 0.55; vagina 0.35.

Female tail elongate, conical; vulva immediately anterior to anus; vagina short with single convolution; egg not seen.

Remarks

Although described from only three specimens,



FIGURES 14–23. *Cloacina cunctabunda* sp. nov., specimens from *Dendrolagus mbaiso*. **14**. Anterior end, lateral view. **15**. Cephalic extremity, lateral view, dorsal aspect on left-hand side. **16**. Cephalic extremity, ventral view. **17**. Submedian cephalic papilla, lateral view. **18**. Cephalic extremity, apical view. **19**. Cephalic extremity, transverse optical section through buccal capsule. **20**. Bursa, apical view. **21**. Gubernaculum, ventral view. **22**. Female tail, lateral view. **23**. Female genital system, lateral view. Scale bars: 22, 23, 0.1 mm; 14–21 0.01 mm.

this species is sufficiently distinctive to allow ready recognition, and comes from a host restricted to isolated localities in Irian Jaya which is unlikely to be sampled extensively in the future (Flannery et al. 1995). Furthermore, this species of *Cloacina* was not found in any other species of tree kangaroo.

C. cunctabunda is distinguished from all congeners except *C. cretheis*, *C. caballeroi*, *C. enyo*, *C. ips* and *C. syphax* in possessing a simple buccal capsule, an elongate, unornamented oesophagus and the external branchlets of the dorsal ray arising before the major bifurcation. The position of the deirid anterior to the nerve ring distinguishes the species from *C. cretheis* and *C. caballeroi*, while the shape of the buccal capsule and the submedian cephalic papillae distinguish it from *C. syphax*. *C. cunctabunda* is distinguished from *C. enyo* on the basis of spicule lengths, which are 1.39–1.57 mm long in *C. cunctabunda* compared with 0.68–0.88 mm in *C. enyo*. *C. cunctabunda* therefore most closely resembles *C. ips*, from which it is distinguished by the number of leaf crown elements (six in *C. cunctabunda*, eight in *C. ips*), in the absence of a dorsal oesophageal tooth which projects prominently into the buccal capsule of *C. ips*, in the shape of the female tail which is slender and elongate in *C. cunctabunda* but short and conical in *C. ips*, and in the shape of the vagina which is straight in *C. ips* but convoluted in *C. cunctabunda*.

Cloacina erigone sp. nov.
(Figs 24–36)

Types: From stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May 1987. Holotype ♂, SAM AHC 31434; allotype ♀, SAM AHC 31435. Paratypes: 4♂, 5♀, SAM AHC 31436, 1♂, 1♀, BMNH 2001.4.10.3–4, 1♂, 1♀, USNPC 91134. Slide preparations of apical views of mouth and bursa, SAM AHC 28380.

Material examined: types.

Description

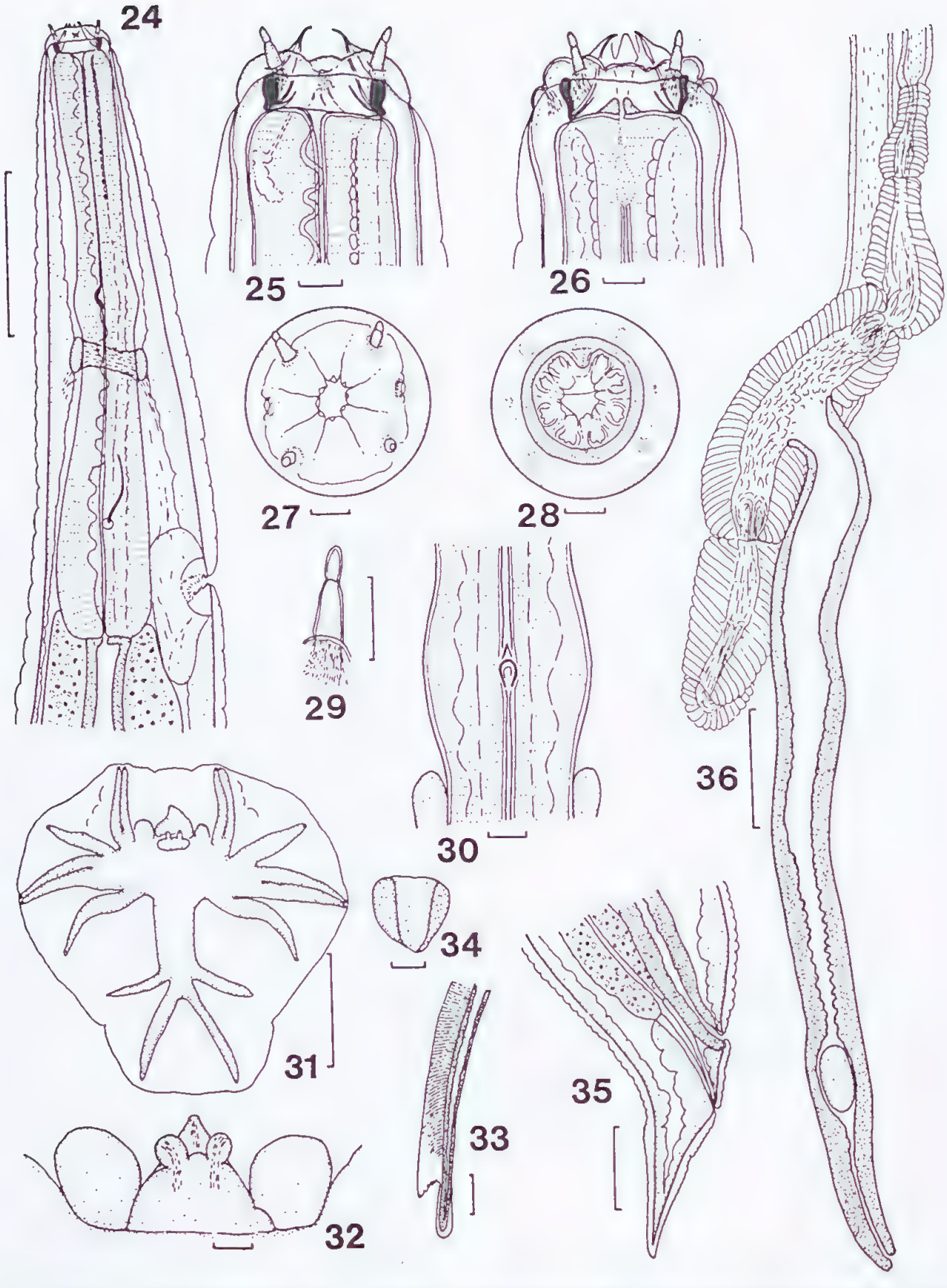
Small nematodes; cervical cuticle slightly inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.015 apart. Submedian cephalic papillae prominent, 0.013 long, projecting anteriorly from peri-oral cuticle; distal segment ovoid, 0.005 long, shorter than cylindrical proximal segment, 0.008 long. Buccal capsule shallow, symmetrical in dorsal and lateral views, circular in transverse section, wider than deep, wall without striations. Leaf crown elements 8 in number, slightly recurved at tips, margins prominently thickened; peri-oral cuticle not inflated into lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, projecting prominently into lumen of buccal capsule. Oesophagus claviform, robust, slightly wider at posterior end; lining with sclerotised bosses extending from anterior end, halfway to nerve ring; single dorsal denticle present in prominent preneural swelling of oesophagus. Nerve ring in mid-oesophageal region; deirids posterior to nerve ring, almost at level of excretory pore; excretory pore at level of oesophago-intestinal junction.

Male. Measurements of 8 specimens, types. Total length 2.88–5.11 (4.02); maximum width 0.18–0.31 (0.26); buccal capsule 0.007–0.010 (0.008) x 0.023–0.035 (0.032); oesophagus 0.26–0.39 (0.34); nerve ring to anterior end 0.14–0.22 (0.18); excretory pore to anterior end 0.25–0.40 (0.33); deirid to anterior end 0.23–0.37 (0.32); spicules 1.35–1.79 (1.59); gubernaculum 0.020–0.030 (0.024) long.

Dorsal ray elongate, broad at origin; external branchlets arise at 1/2 length, immediately before major bifurcation; angle of bifurcation acute; external branchlets shorter than internals, directed laterally, not reaching margin of bursa; internal branchlets originate immediately after externals, directed postero-laterally, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, slightly wider than long. Spicule tip blunt; ala terminates abruptly anterior to spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 8 specimens, types. Total length 3.56–4.81 (4.39); maximum width 0.31–0.48 (0.41); buccal capsule 0.008–0.010 (0.009) x 0.033–0.045 (0.039); oesophagus 0.35–0.44 (0.39); nerve ring to anterior end 0.16–0.23 (0.20); excretory pore to anterior end 0.21–0.43 (0.34); deirid to anterior end 0.26–0.37 (0.32); tail 0.16–0.19 (0.17); vulva to posterior end 0.24–0.28 (0.26); vagina 0.53–0.99 (0.75); egg 0.055–0.070 (0.062) x 0.030–0.035 (0.031).

Female tail short, conical; vulva immediately anterior to anus; vagina elongate, straight; egg ellipsoidal.



FIGURES 24–36. *Cloacina erigone* sp. nov., types. **24.** Anterior end, lateral view. **25.** Cephalic extremity, lateral view, dorsal aspect on left-hand side. **26.** Cephalic extremity, dorsal view. **27.** Cephalic extremity, apical view. **28.** Cephalic extremity, transverse optical section through buccal capsule. **29.** Submedian cephalic papilla, lateral view. **30.** Preneural oesophageal swelling showing dorsal denticle, dorsal view. **31.** Bursa, apical view. **32.** Genital cone, dorsal view. **33.** Spicule tip, lateral view. **34.** Gubernaculum, ventral view. **35.** Female tail, lateral view. **36.** Female genital system, lateral view. Scale bars: 24, 31, 35, 36, 0.1 mm; 25–30, 32–34, 0.01 mm.

Remarks

Cloacina erigone sp. nov. is characterised by having submedian cephalic papillae with an elongate proximal segment, a shallow, unornamented buccal capsule, eight leaf crown elements, deirid posterior to the nerve ring, a dorsal ray with the external branchlets arising before the main bifurcation and a straight vagina. In these characters, *C. erigone* resembles *C. caballeroi*, *C. cretheis*, *C. enyo*, *C. ips* and *C. syphax*. It differs from all of these species, however, in having bosses lining the anterior part of the vagina and a single dorsal denticle. Species with a symmetrical buccal capsule, oesophageal bosses and a single dorsal denticle are *C. australis*, *C. dis* Beveridge, 1998, *C. hecuba* Beveridge, 1998, *C. io* Beveridge, 1998, *C. laius*, *C. leto* Beveridge, 1998, *C. minor* (Davey & Wood, 1938) and *C. tyro* Beveridge, 1998. However, in none of these species is the deirid posterior to the nerve ring, and in none do the external branchlets of the dorsal ray arise before the principal bifurcation.

This species has, thus far, been found only in *Do. hageni*.

Cloacina eurynome sp. nov.
(Figs 37–49)

Types: From stomach of *Dendrolagus dorianus*, Tembagapura, Irian Jaya, coll. T. Flannery, 19.v.1994, 23.v.1994. Holotype ♂, SAM AHC 31437; allotype ♀, SAM AHC 31438. Paratypes: 4♂, 9♀, SAM AHC 31439, 1♂, 2♀, SAM AHC 31440, 1♂, 1♀, BMNH 2001.4.10.5–6, 1♂, 1♀, USNPC 91135. Slide preparations of spicules, apical views of mouth and bursa, SAM AHC 28381.

Material examined: From *Dendrolagus dorianus*: types. From *Dendrolagus scottae*: 4♀, Sweipini, Sandaun Province, Papua New Guinea, coll. T. Flannery, 15.vi.1991, SAM AHC 31441.

Description

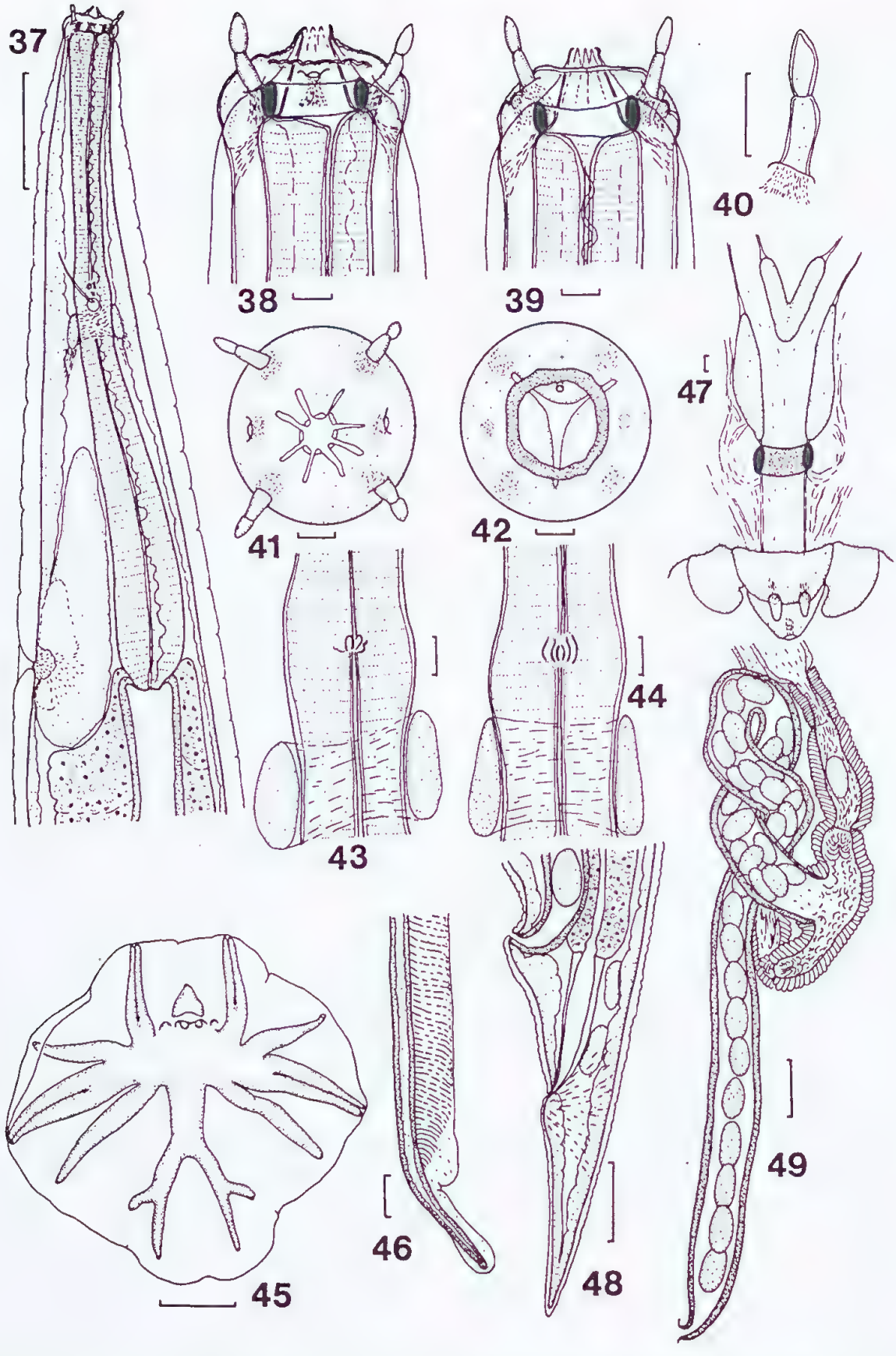
Small nematodes; cervical cuticle slightly inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.030 apart. Submedian cephalic papillae prominent, 0.018 long, projecting anteriorly from peri-oral cuticle; distal segment ovoid, pointed apically, 0.008 long, shorter than cylindrical proximal segment, 0.010 long. Buccal capsule shallow, symmetrical in dorsal and lateral views, approximately octagonal in transverse section, wider than deep, wall without striations. Leaf crown elements 8 in number, slightly recurved at tips; peri-oral cuticle not inflated into lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus claviform, slender, only slightly wider at posterior end; lining without sclerotised bosses; three poorly developed denticles, one dorsal and two subventral, present in lumen of oesophagus immediately anterior to nerve ring; preneural swelling of oesophagus small. Nerve ring in mid-oesophageal region; deirids at level of nerve ring; excretory pore at level of oesophago-intestinal junction.

Male. Measurements of 7 specimens, types. Total length 8.75–10.67 (9.53); maximum width 0.39–0.48 (0.45); buccal capsule 0.007–0.010 (0.008) x 0.027–0.030 (0.029); oesophagus 0.57–0.64 (0.59); nerve ring to anterior end 0.26–0.28 (0.27); excretory pore to anterior end 0.54–0.62 (0.58); deirid to anterior end 0.24–0.32 (0.28); spicules 3.57–3.98 (3.77); gubernaculum 0.015–0.020 (0.019) long.

Dorsal ray elongate, broad at origin; major bifurcation occurs at 1/3 length; angle of bifurcation acute; external branchlets arise midway between major bifurcation and tip, much shorter than internals, directed laterally or postero-laterally, not reaching margin of bursa; internal branchlets directed postero-laterally, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, wider than long. Spicule tip blunt, gently curved; ala terminates abruptly anterior to spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 10 specimens, types. Total length 10.19–13.28 (11.50); maximum width 0.52–0.75 (0.60); buccal capsule 0.005–0.013 (0.008) x 0.030–0.035 (0.031); oesophagus 0.61–0.73 (0.65); nerve ring to anterior end 0.25–0.28 (0.27); excretory pore to anterior end 0.52–0.71 (0.60); deirid to anterior end 0.18–0.34 (0.27); tail 0.22–0.29 (0.25); vulva to posterior end 0.31–0.46 (0.39); vagina 1.57–1.85 (1.75); egg 0.080–0.095 (0.086) x 0.040–0.050 (0.046).

Female tail slender, conical; vulva immediately anterior to anus; vagina elongate, straight distally, recurrent anterior to vestibule, recurrent section twisted in characteristic figure of eight formation; egg ellipsoidal.



FIGURES 37–49. *Cloacina eurynome* sp. nov., types. **37**. Anterior end, lateral view. **38**. Cephalic extremity, lateral view, dorsal aspect on right-hand side. **39**. Cephalic extremity, ventral view. **40**. Submedian cephalic papilla, lateral view. **41**. Cephalic extremity, apical view. **42**. Cephalic extremity, transverse optical section through buccal capsule. **43**. Preneural oesophageal swelling showing denticles, lateral view, dorsal aspect on right-hand side. **44**. Preneural oesophageal swelling showing denticles, ventral view. **45**. Bursa, apical view. **46**. Spicule tip, lateral view. **47**. Gubernaculum, genital cone and thickenings of spicule sheaths, dorsal view. **48**. Female tail, lateral view. **49**. Female genital system, lateral view. Scale bars: 37, 45, 48, 49, 0.1 mm; 38–44, 46, 47, 0.01 mm.

Remarks

The presence of three preneural denticles at the same level in the oesophagus distinguishes *C. eurynome* from all congeners except *C. hera* Beveridge, 1998, *C. hermes* Beveridge, 1998 and *C. hestia* Beveridge, 1998, all of which are parasites of grey kangaroos, *Macropus fuliginosus* (Desmarest, 1817) and *M. giganteus* Shaw, 1790 in eastern and southern Australia (Beveridge 1998) and *C. daveyi* Mawson, 1977 in the wallaroo, *M. robustus* Gould, 1841. *C. eurynome* is distinguished from the species in grey kangaroos in having the deirid at the level of the nerve ring rather than well anterior to it and in having eight rather than six leaf crown elements. It is distinguished from *C. daveyi* which has cephalic papillae with large, globose, medially directed distal segments. The denticles in *C. eurynome* are vestigial, a feature found only in *C. hestia*. *C. eurynome* is distinguished from all congeners other than *C. syphax*, from *Dorcopsulus vanheurni*, also from Papua New Guinea, in the morphology of the vagina, which exhibits a highly characteristic recurrent loop, anterior to the vestibule, twisted in a figure of eight formation. *C. eurynome* differs from *C. syphax* in possessing denticles, in having a straight rather than a sinuous anterior margin to the buccal capsule, and in having the external branchlets of the dorsal ray arise after the major bifurcation

Cloacina hecale sp. nov.
(Figs 50–61)

Types: From stomach of *Dendrolagus dorianus*, Lake Trist, Papua New Guinea, coll. I. Redmond, 1979. Holotype ♂, BMNH 1981.4506; allotype ♀, BMNH 1981.4507. Paratypes: 49♂, 88♀, BMNH 1981.4508–4535. Slide preparations of apical views of bursa and mouth, SAM AHC 28383.

Material examined: From *Dendrolagus dorianus*: types.

Description

Robust nematodes; cervical cuticle slightly inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.023 apart. Submedian cephalic papillae prominent, 0.017 long, projecting anteriorly from peri-oral cuticle; distal segment conical, 0.007 long, only slightly shorter than cylindrical proximal segment, 0.010 long. Buccal capsule shallow, symmetrical in dorsal and lateral views, circular in transverse section, wider than deep, wall without striations; anterior margin slightly undulant. Leaf crown elements 8 in number, slightly recurved at tips; peri-oral cuticle not inflated into lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus claviform, slender, slightly wider at posterior end; lining without sclerotised bosses; denticles absent. Nerve ring in anterior oesophageal region; deirids anterior to nerve ring; excretory pore at level of oesophago-intestinal junction.

Male. Measurements of 10 specimens, types. Total length 9.44–13.86 (11.82); maximum width 0.50–0.67 (0.60); buccal capsule 0.010–0.013 (0.011) x 0.035–0.040 (0.039); oesophagus 0.76–0.95 (0.87); nerve ring to anterior end 0.30–0.32 (0.31); excretory pore to anterior end 0.52–0.98 (0.80); deirid to anterior end 0.17–0.26 (0.23); spicules 3.90–5.05 (4.54); gubernaculum 0.040 long.

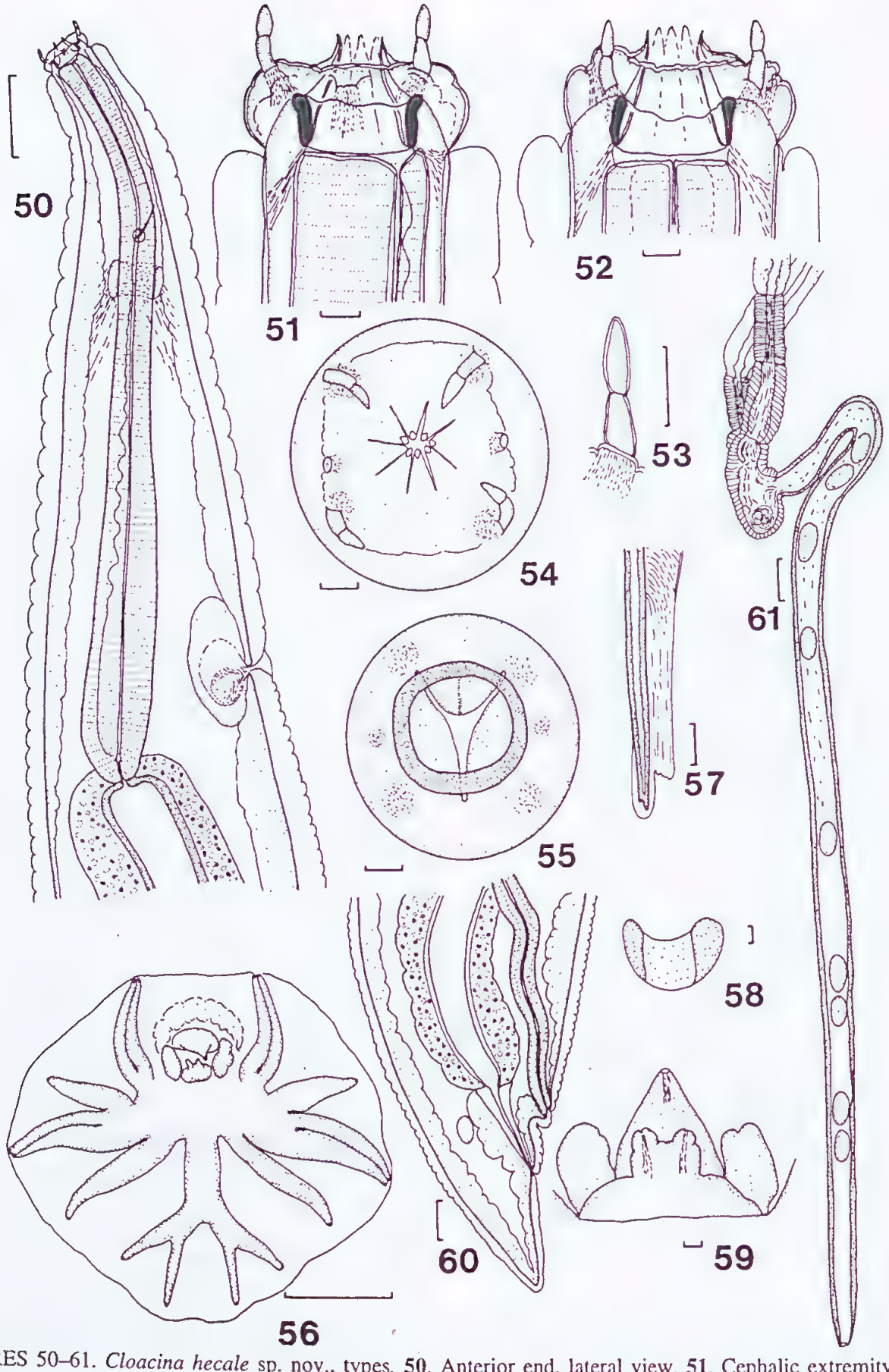
Dorsal ray broad at origin; major bifurcation occurs at 1/2 length; external branchlets arise immediately after major bifurcation, as long as internals, though more robust, directed postero-laterally, not reaching margin of bursa; internal branchlets directed posteriorly, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, wider than long. Spicule minutely bifid at tip; ala terminates abruptly anterior to spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 5 specimens, types. Total length 19.6–22.9 (21.3); maximum width 0.64–0.91 (0.81); buccal capsule 0.010 (0.010) x 0.040 (0.040); oesophagus 0.95–1.02 (0.97); nerve ring to anterior end 0.25–0.29 (0.27); excretory pore to anterior end 0.63–0.86 (0.70); deirid to anterior end 0.19–0.29 (0.22); tail 0.13–0.30 (0.21); vulva to posterior end 0.18–0.43 (0.28); vagina 2.22–2.57 (2.40); vestibule 0.27; sphincter 0.22; infundibulum 0.17; egg 0.090–0.110 (0.096) x 0.045–0.050 (0.048).

Female tail short, conical; vulva immediately anterior to anus; vagina elongate, straight, extends slightly anterior to vestibule with short recurrent section; egg ellipsoidal.

Remarks

Cloacina hecale sp. nov. is a robust species characterised by long spicules and an elongate



FIGURES 50–61. *Cloacina hecale* sp. nov., types. **50**. Anterior end, lateral view. **51**. Cephalic extremity, lateral view, dorsal aspect on right-hand side. **52**. Cephalic extremity, dorsal view. **53**. Submedian cephalic papilla, lateral view. **54**. Cephalic extremity, apical view. **55**. Cephalic extremity, transverse optical section through buccal capsule. **56**. Bursa, apical view. **57**. Spicule tip, lateral view. **58**. Gubernaculum, ventral view. **59**. Genital cone, dorsal view. **60**. Female tail, lateral view. **61**. Female genital system, lateral view. Scale bars: 50, 56, 60, 61, 0.1 mm; 51–55, 57–59, 0.01 mm.

vagina, slightly recurrent at its anterior extremity. The length of the vagina relative to the sizes of vestibule, sphincter and infundibulum are given in the description in this case to emphasise the extreme length of the vagina. The other features of the species are unremarkable, with cephalic papillae bearing a distal segment with an acute tip, almost equal in length to the proximal segment, eight leaf crown elements, a symmetrical buccal capsule, a slender, unornamented oesophagus, the deirid anterior to the nerve ring and the external branchlets of the dorsal ray arising after the principal bifurcation. These features together with the length of the spicules (> 3.0 mm) differentiate *C. hecale* from congeners except *C. clymene* Beveridge, 1998, *C. curta* Johnston & Mawson, 1938, *C. liebigi* Johnston & Mawson, 1938, *C. longispiculata* Johnston & Mawson, 1939, *C. nike* Beveridge, 1998, *C. robertsi* Johnston & Mawson, 1939, *C. smalesae* Mawson, 1975 and *C. solymus*. *C. hecale* is differentiated from *C. clymene* and *C. robertsi* which have six elements to the leaf crown and lip-like inflations of the peri-oral cuticle attached to each element of the leaf crown. *C. curta*, *C. liebigi*, *C. longispiculata* and *C. smalesae* all have six leaf crown elements rather than eight and the vagina is prominently recurrent in these species rather than having a short anterior recurrent section. In addition, *C. liebigi*, *C. longispiculata* and *C. smalesae* have the cervical cuticle inflated so as to form 'shoulders' in the oesophageal region. *C. nike* has submedian cephalic papillae in which the distal segment is much shorter than the proximal segment and has a sinuous vagina and a longer, slender tail in the female. *C. solymus* has a robust subcylindrical oesophagus but the submedian cephalic papillae are tiny and the anterior margin of the buccal capsule is undulate. Therefore, *C. hecale* is readily distinguishable from all known congeners.

Cloacina hyperea sp. nov.
(Figs 62–74)

Types: From stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May, 1987. Holotype ♂, SAM AHC 31442; allotype ♀, SAM AHC 31443. Paratypes: 12♂, 8♀, SAM AHC 31444, 1♂, 1♀, BMNH 2001.4.10.7–8, 1♂, 1♀, USNPC 91136. Slide preparations of apical views of mouth and bursa, SAM AHC 28382.

Material examined: From *Dorcopsis hageni*: types.

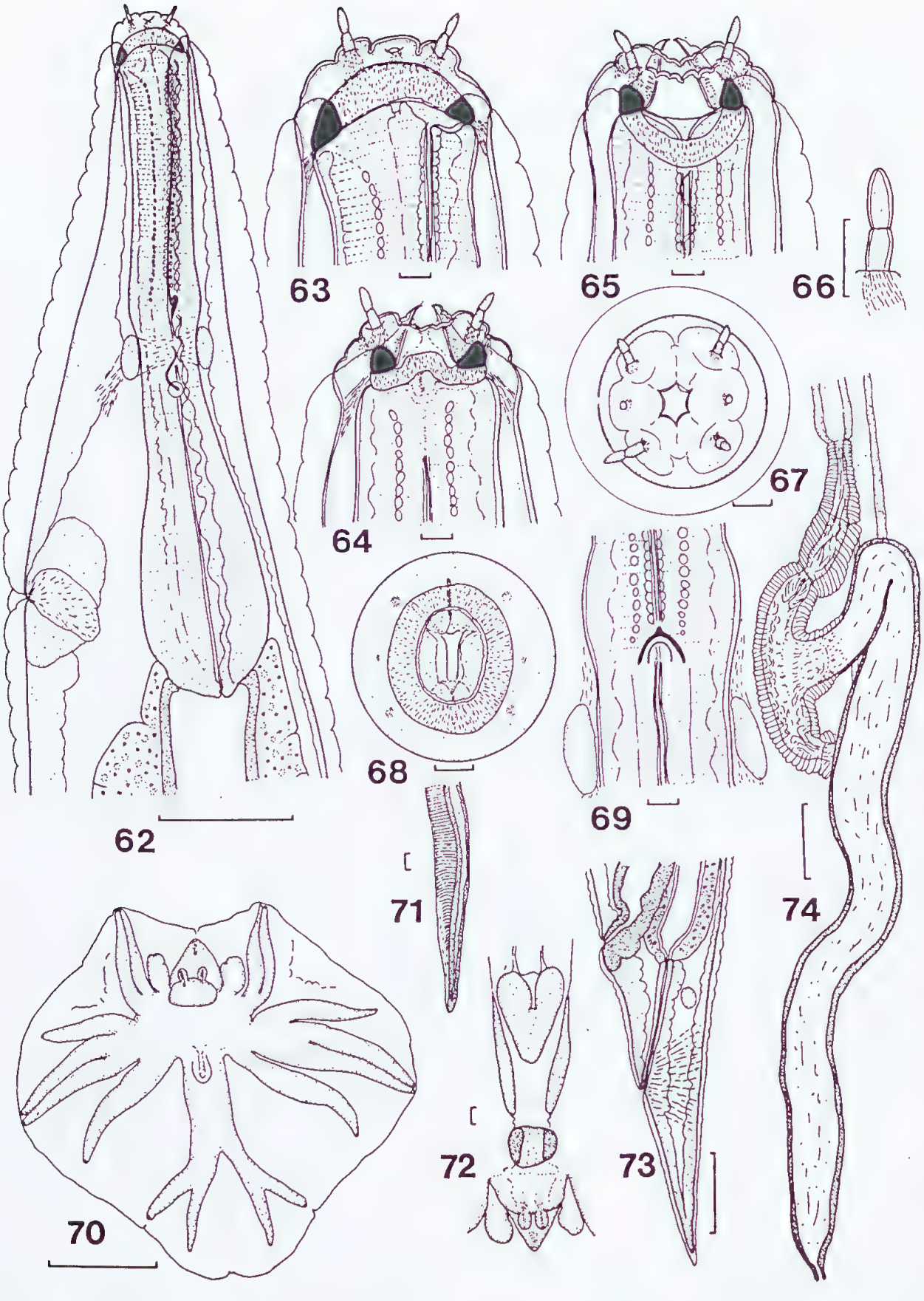
Description

Robust nematodes; cervical cuticle slightly inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.034 apart. Submedian cephalic papillae prominent, 0.015 long, projecting anteriorly from peri-oral cuticle; distal segment conical, 0.007 long, only slightly shorter than cylindrical proximal segment, 0.008 long. Buccal capsule shallow, symmetrically arched anteriorly in lateral views; in dorsal views, buccal capsule arches anteriorly over dorsal oesophageal gland; in ventral views, curves posteriorly; oval and dorso-ventrally elongate in transverse section, wider than deep, wall with prominent striations; anterior margin smooth, except on dorsal aspect. Leaf crown elements 6 in number, slightly recurved at tips; peri-oral cuticle slightly inflated into lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, projecting prominently into lumen of buccal capsule. Oesophagus claviform, robust; lining with sclerotised bosses extending to level of nerve ring; single dorsal oesophageal denticle present in prominent preneural swelling. Nerve ring in mid-oesophageal region; deirids at level of nerve ring; excretory pore at level of, or slightly anterior to, oesophago-intestinal junction.

Male. Measurements of 10 specimens, types. Total length 4.20–5.21 (4.56); maximum width 0.26–0.40 (0.34); buccal capsule 0.013–0.020 (0.016) x 0.055–0.060 (0.056); oesophagus 0.42–0.50 (0.47); nerve ring to anterior end 0.20–0.24 (0.22); excretory pore to anterior end 0.35–0.51 (0.43); deirid to anterior end 0.25–0.34 (0.31); spicules 2.25–2.49 (2.37); gubernaculum 0.020–0.030 (0.026) long.

Dorsal ray broad at origin; major bifurcation occurs at 1/2 length; angle of bifurcation acute; external branchlets arise after major bifurcation, as long as internals, directed postero-laterally, not reaching margin of bursa; internal branchlets directed posteriorly, not reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, slightly wider than long. Spicule tip blunt; ala diminishes gradually in width towards spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 6 specimens, types. Total length 5.25–6.14 (5.67); maximum width



FIGURES 62–74. *Cloacina hyperea* sp. nov., types. **62**. Anterior end, lateral view. **63**. Cephalic extremity, lateral view, dorsal aspect on right-hand side. **64**. Cephalic extremity, dorsal view. **65**. Cephalic extremity, ventral view. **66**. Submedian cephalic papilla, lateral view. **67**. Cephalic extremity, apical view. **68**. Cephalic extremity, transverse optical section through buccal capsule. **69**. Preneural swelling of oesophagus, dorsal view, showing denticle. **70**. Bursa, apical view. **71**. Spicule tip, lateral view. **72**. Gubernaculum and genital cone, dorsal view. **73**. Female tail, lateral view. **74**. Female genital system, lateral view. Scale bars: 62, 70, 73, 74, 0.1 mm; 63–69, 71,72, 0.01 mm.

0.32–0.45 (0.39); buccal capsule 0.013–0.018 (0.016) x 0.058–0.060 (0.059); oesophagus 0.46–0.52 (0.49); nerve ring to anterior end 0.20–0.23 (0.22); excretory pore to anterior end 0.35–0.50 (0.45); deirid to anterior end 0.24–0.33 (0.29); tail 0.19–0.26 (0.23); vulva to posterior end 0.36–0.43 (0.39); vagina 0.96–1.24 (1.07).

Female tail slender, conical; vulva immediately anterior to anus; vagina elongate, sinuous, extends slightly anterior to vestibule with short recurrent section; egg not seen.

Remarks

The anteriorly arched buccal capsule wall distinguishes *C. hyperea* sp. nov. from all congeners except *C. circe* Beveridge, 1999 and *C. laius* Beveridge, 1999, both of which occur in the quokka, *Setonix brachyurus* (Quoy & Gaimard, 1830) in the south-west of Western Australia, and from *C. nephele* sp. nov., described below. *C. hyperea* is distinguished from *C. circe* in possessing sclerotised bosses and a dorsal denticle in the oesophagus. It is differentiated from *C. laius* in having the buccal capsule less prominently arched, in having submedian cephalic papillae of a different shape, with both segments of approximately equal length, whereas in *C. laius* the proximal segment is almost twice as long as the distal segment. In addition, the spicules are 2.25–2.49 mm long in *C. hyperea* compared with 1.50–1.97 mm in *C. laius* and the vagina is commensurately longer, being 0.96–1.24 mm in *C. hyperea* compared with 0.71–0.92 mm in *C. laius*. In *C. hyperea* the internal and external branchlets of the dorsal ray are of approximately equal length whereas in *C. laius* the external branchlets are much shorter than the internal branchlets. *C. nephele* sp. nov. has lateral lips, which are absent in *C. hyperaea*, and a bulbous proximal segment to the cephalic papilla.

Cloacina nephele sp. nov.
(Figs 75–89)

Types: From stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May, 1987. Holotype ♂, SAM AHC 31445; allotype ♀, SAM AHC 31446. Paratypes: 3♂, 2♀, SAM AHC 31447, 1♂, BMNH 2001.4.10.9, 1♂, USNPC 91137. Slide preparations of apical views of mouth and bursa, SAM AHC 28384.

Material examined: From *Dorcopsis hageni:* types.

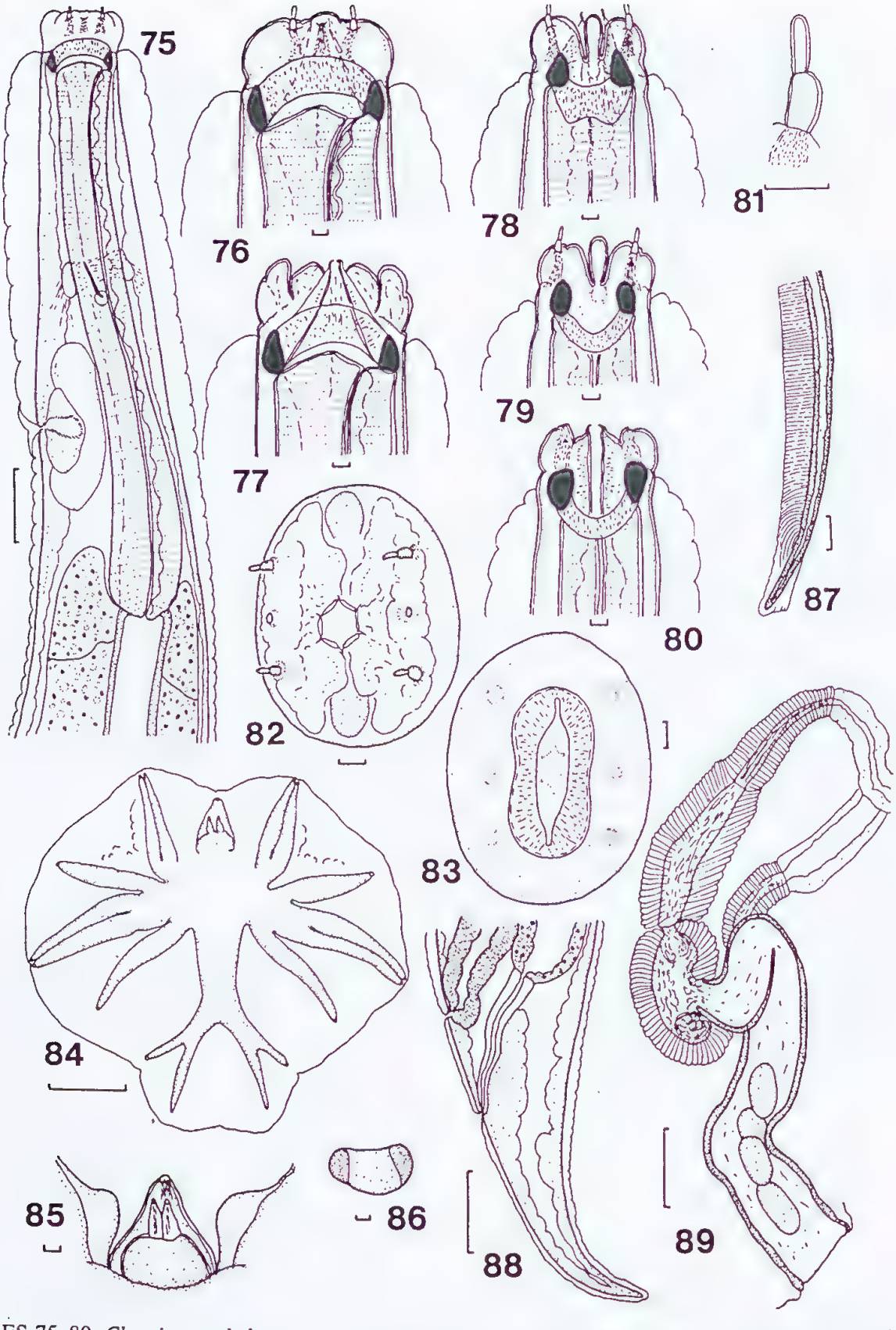
Description

Robust nematodes; cervical cuticle prominently inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.040 apart. Submedian cephalic papillae prominent, 0.020 long, projecting anteriorly from inflated peri-oral cuticle; distal segment slender, conical, 0.010 long, as long as robust, asymmetrical proximal segment, 0.010 long. Buccal capsule shallow, symmetrically arched anteriorly in lateral views; dorsally, arches anteriorly over dorsal oesophageal gland; ventrally, curves posteriorly; oval and dorso-ventrally elongate in transverse section, wider than deep, wall with prominent striations; anterior margin smooth. Leaf crown elements 6 in number, recurved at tips; peri-oral cuticle inflated into lip-like lobes attached to each element; extra dorsal and ventral projections of peri-oral cuticle present, separate from lateral arcades of amphids and submedian papillae, giving the appearance of lips. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus claviform, robust; lining without sclerotised bosses; denticles absent in preneural region. Nerve ring in mid-oesophageal region; deirids at level of nerve ring; excretory pore between nerve ring and oesophago-intestinal junction.

Male. Measurements of 5 specimens, types. Total length 6.08–7.40 (6.66); maximum width 0.33–0.37 (0.35); buccal capsule 0.023–0.030 (0.026) x 0.090 (0.090); oesophagus 0.69–0.73 (0.71); nerve ring to anterior end 0.28–0.30 (0.29); excretory pore to anterior end 0.48–0.53 (0.51); deirid to anterior end 0.31–0.36 (0.34); spicules 1.96–2.10 (2.03); gubernaculum 0.035–0.040 (0.039) long.

Dorsal ray broad at origin, narrowing posteriorly; major bifurcation occurs at 1/2 length; angle of bifurcation acute; external branchlets arise after major bifurcation, shorter than internals, directed postero-laterally, not reaching margin of bursa; internal branchlets directed posteriorly, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, slightly wider than long. Spicule tip blunt; ala diminishes gradually in width towards spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 3 specimens, types. Total length 5.94–7.87 (7.02); maximum width 0.34–0.63 (0.50); buccal capsule 0.025–0.030



FIGURES 75–89. *Cloacina nephele* sp. nov., types. **75**. Anterior end, lateral view. **76**. Cephalic extremity, lateral view, dorsal aspect on right-hand side. **77**. Cephalic extremity, lateral view, dorsal aspect on right-hand side, median optical section showing leaf crown elements and inflation of cephalic collar. **78**. Cephalic extremity, dorsal view. **79**. Cephalic extremity, ventral view. **80**. Cephalic extremity, ventral view, median optical section showing leaf crown elements. **81**. Submedian cephalic papilla, lateral view. **82**. Cephalic extremity, apical view. **83**. Cephalic extremity, transverse optical section through buccal capsule. **84**. Bursa, apical view. **85**. Genital cone, dorsal view. **86**. Gubernaculum, ventral view. **87**. Spicule tip, lateral view. **88**. Female tail, lateral view. **89**. Female genital system, lateral view. Scale bars: 75, 84, 88, 89, 0.1 mm; 76–83, 85–87, 0.01 mm.

(0.027) x 0.100 (0.100); oesophagus 0.72–0.79 (0.76); nerve ring to anterior end 0.29–0.32 (0.30); excretory pore to anterior end 0.46–0.58 (0.52); deirid to anterior end 0.30–0.31 (0.31); tail 0.31–0.39 (0.35); vulva to posterior end 0.43–0.55 (0.48); vagina 0.51–0.66 (0.59); egg 0.080–0.085 (0.083) x 0.040–0.045 (0.043).

Female tail slender, conical; vulva immediately anterior to anus; vagina elongate, sinuous, extends slightly anterior to vestibule with short recurrent section; egg ellipsoidal.

Remarks

C. nephele sp. nov. closely resembles *C. circe*, *C. laius* and *C. hyperea* in having an anteriorly arched buccal capsule. It differs from *C. laius* and *C. hyperea* in lacking oesophageal bosses and denticles, and differs from *C. circe* in having a markedly inflated cervical cuticle, cephalic papillae in which the distal segment is not oriented medially, and a recurrent vagina. It differs from all of these species in having a swollen cephalic collar and lip-like inflations of the peri-oral cuticle attached to each leaf crown element. The dorsal and ventral 'lips' are unique within the genus.

Cloacina oweni sp. nov.
(Figs 90–101)

Synonyms: *Cloacina* sp. nov. of Beveridge, 1998, p. 506 (*Macropus agilis*).

Types: From stomach of *Macropus agilis*, Bula Plain, Bensbach, Papua New Guinea, coll. I. Owen, May, 1998. Holotype ♂, SAM AHC 31448; allotype ♀, SAM AHC 31449. Paratypes: 51♂, 55♀, SAM AHC 31450, 1♂, 1♀, BMNH 1998.9.28.11–12.

Material examined: From *Macropus agilis*: types; 1♂, 1♀, Dari, Bensbach, Papua New Guinea, SAM AHC 11719.

Description

Robust nematodes; cervical cuticle slightly inflated to level of excretory pore; transverse cuticular annulations widely spaced, 0.030 apart. Submedian cephalic papillae prominent, 0.013 long, projecting anteriorly from inflated peri-oral cuticle; distal segment ovoid, 0.004 long, shorter than cylindrical proximal segment, 0.008 long. Buccal capsule shallow, symmetrical in lateral and dorso-ventral views; octagonal in transverse section, wider than deep, wall without prominent striations; anterior margin smooth. Leaf crown elements 8 in number, recurved at tips; peri-oral cuticle inflated into lip-like lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus claviform, robust; lining without sclerotised bosses; single dorsal denticle present at level of nerve ring; preneural swelling absent. Nerve ring in mid-oesophageal region; deirids in anterior oesophageal region; excretory pore between nerve ring and oesophago-intestinal junction.

Male. Measurements of 10 specimens, types. Total length 5.48–7.50 (6.73); maximum width 0.26–0.43 (0.34); buccal capsule 0.015–0.025 (0.019) x 0.045–0.070 (0.056); oesophagus 0.53–0.65 (0.60); nerve ring to anterior end 0.25–0.32 (0.27); excretory pore to anterior end 0.26–0.53 (0.44); deirid to anterior end 0.10–0.16 (0.12); spicules 2.19–2.67 (2.46); gubernaculum 0.025–0.040 (0.031) long.

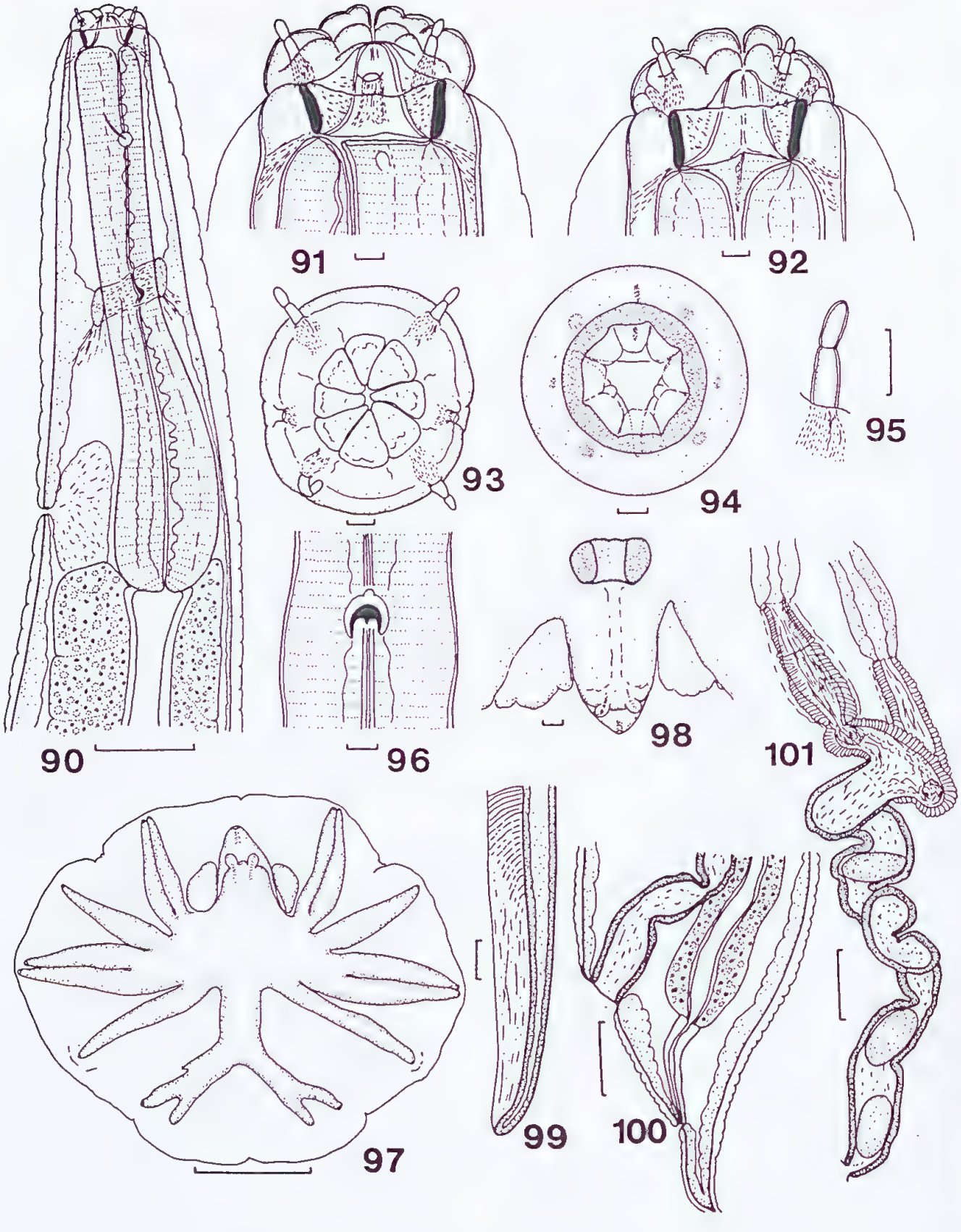
Dorsal ray broad at origin; major bifurcation occurs at 1/3 length; angle of bifurcation obtuse; external branchlets arise after major bifurcation, near extremity of ray, slightly longer and more robust than internals, directed postero-laterally, not reaching margin of bursa; internal branchlets directed postero-laterally, not reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, slightly wider than long. Spicule tip blunt, slightly recurved; ala diminishes gradually in width towards spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 10 specimens, types. Total length 6.70–9.36 (8.06); maximum width 0.30–0.61 (0.46); buccal capsule 0.015–0.025 (0.020) x 0.045–0.075 (0.057); oesophagus 0.55–0.76 (0.64); nerve ring to anterior end 0.24–0.33 (0.28); excretory pore to anterior end 0.32–0.61 (0.48); deirid to anterior end 0.09–0.16 (0.11); tail 0.14–0.21 (0.17); vulva to posterior end 0.27–0.34 (0.31); vagina 0.45–0.70 (0.58); egg 0.090–0.100 (0.093) x 0.040–0.050 (0.048).

Female tail short, conical; vulva immediately anterior to anus; vagina elongate, convoluted, not recurrent; egg ellipsoidal.

Remarks

The prominent lips and symmetrical buccal capsule distinguish *C. oweni* sp. nov. from all congeners except *C. artemis* Beveridge, 1998, *C. caenis* Beveridge, 1998, *C. clymene*, *C. dindymene* Beveridge, 1998, *C. hypsipyle*, *C.*



FIGURES 90–101. *Cloacina oweni* sp. nov., types. **90**. Anterior end, lateral view. **91**. Cephalic extremity, lateral view, dorsal aspect on left-hand side. **92**. Cephalic extremity, dorsal view. **93**. Cephalic extremity, apical view. **94**. Cephalic extremity, transverse optical section through buccal capsule. **95**. Submedian cephalic papilla, lateral view. **96**. Preneural region of oesophagus, showing denticle, dorsal view. **97**. Bursa, apical view. **98**. Genital cone, dorsal view and gubernaculum. **99**. Spicule tip, lateral view. **100**. Female tail, lateral view. **101**. Female genital system, lateral view. Scale bars: 90, 97, 100, 101, 0.1 mm; 91–96, 98, 99, 0.01 mm.

linstowi Johnston & Mawson, 1940, *C. maia* Beveridge, 1998, *C. parva*, *C. robertsi*, *C. smalesae*, *C. thetidis* Johnston & Mawson, 1939 and *C. wallabiae* Johnston & Mawson, 1939. The presence of a single dorsal denticle in the oesophagus and the lack of oesophageal bosses distinguishes it from all of these species except *C. dindymene*. It differs from *C. dindymene* in the shape of the submedian cephalic papillae which have elongated distal segments in *C. dindymene*, and in the shape of the dorsal ray, the bifurcations of which form an acute angle in *C. dindymene* rather than the obtuse angle seen in *C. oweni*. In features of the head, *C. oweni* is most likely to be confused with *C. robertsi*, found in rock wallabies of the genus *Petrogale* Gray, 1837 in eastern Australia. *C. oweni* is readily differentiated, however, by the oesophageal denticle and the lack of a prominently recurrent vagina as exhibited by *C. robertsi*.

C. oweni is abundant in the stomachs of agile wallabies in the Bula Plain region of Papua New Guinea, but has not been found in the same host species in northern Australia in spite of relatively intensive examination of this host in all of the northern states (Speare et al. 1983; Beveridge et al. 1998). More surprising is the close resemblance of this species to congeners occurring in rock wallabies in Australia, a relationship for which no simple explanation currently exists.

Cloacina papuensis sp. nov.
(Figs 102–115)

Types: From stomach of *Macropus agilis*, Bula Plain, Bensbach, Papua New Guinea, coll. I. Owen, May, 1998. Holotype ♂, SAM AHC 31451; allotype ♀, SAM AHC 31452. Paratypes: 5♂, 6♀, SAM AHC 31453, 1♂, 1♀, BMNH 1998.9.28.13–14. Slide preparations of apical view of mouth and bursa, SAM AHC 28386.

Material examined: From *Macropus agilis*: types.

Description

Small nematodes; cervical cuticle not inflated; transverse cuticular annulations widely spaced, 0.010 apart. Submedian cephalic papillae small, conical, 0.006 long, projecting anteriorly from peri-oral cuticle; distal segment ovoid, 0.002 long, shorter than cylindrical proximal segment, 0.004 long. Buccal capsule shallow, symmetrical in lateral and dorso-ventral views; circular in transverse section, wider than deep, wall without prominent striations; anterior margin smooth. Leaf crown elements 8 in number, recurved at tips; peri-oral cuticle not inflated into lip-like lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland in prominent, bilobed, tooth-like structure projecting into lumen of buccal capsule; each ventral sector with 2 triangular sclerotised projections. Oesophagus claviform, slender; lining without sclerotised bosses; single dorsal denticle present immediately anterior to nerve ring; preneural swelling present. Nerve ring in mid-oesophageal region; deirids in anterior oesophageal region; excretory pore between nerve ring and oesophago-intestinal junction.

Male. Measurements of 5 specimens, types. Total length 3.18–5.09 (4.57); maximum width 0.18–0.32 (0.23); buccal capsule 0.007–0.010 (0.008) x 0.020–0.026 (0.021); oesophagus 0.31–0.41 (0.36); nerve ring to anterior end 0.16–0.17 (0.17); excretory pore to anterior end 0.20–0.34 (0.28); deirid to anterior end 0.08–0.11 (0.10); spicules 1.84–2.26 (2.05); gubernaculum 0.025–0.030 (0.029) long.

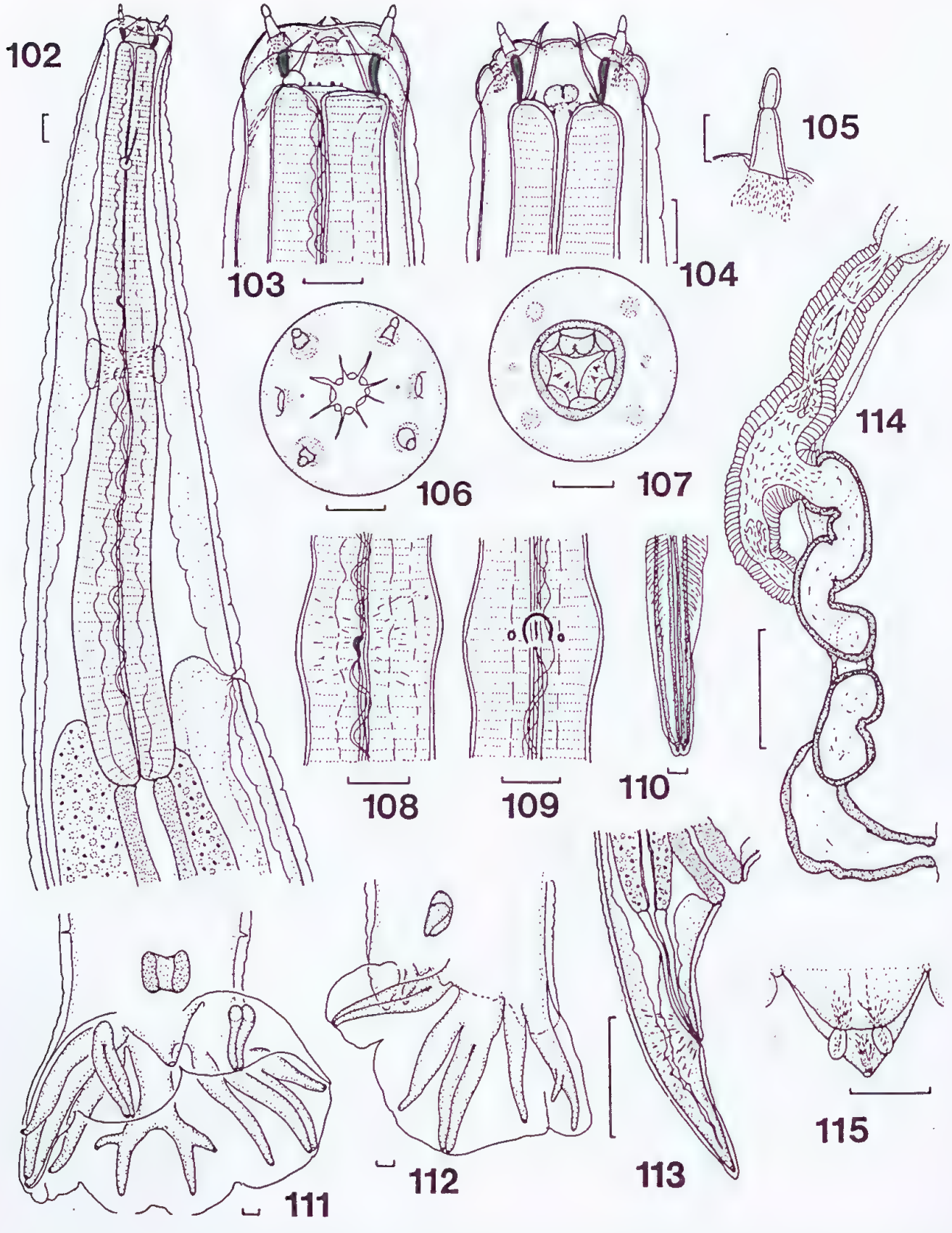
Dorsal ray broad at origin; major bifurcation occurs at 1/2 length; angle of bifurcation acute; external branchlets arise after major bifurcation, shorter and more robust than internals, directed postero-laterally, not reaching margin of bursa; internal branchlets directed posteriorly, not reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, slightly wider than long. Spicule tip bifid; ala diminishes gradually in width towards spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 5 specimens, types. Total length 5.14–6.05 (5.57); maximum width 0.25–0.36 (0.32); buccal capsule 0.005–0.008 (0.007) x 0.020–0.025 (0.023); oesophagus 0.35–0.39 (0.38); nerve ring to anterior end 0.17–0.18 (0.17); excretory pore to anterior end 0.23–0.38 (0.33); deirid to anterior end 0.07–0.011 (0.09); tail 0.14–0.22 (0.19); vulva to posterior end 0.30–0.44 (0.39); vagina 0.47–0.63 (0.53); egg 0.070–0.085 (0.080) x 0.040–0.050 (0.046).

Female tail short, conical; vulva immediately anterior to anus; vagina elongate, convoluted, not recurrent; egg ellipsoidal.

Remarks

The simple, symmetrical buccal capsule, lack of



FIGURES 102–115. *Cloacina papuensis* sp. nov., types. **102**. Anterior end, lateral view. **103**. Cephalic extremity, lateral view, dorsal aspect on left-hand side. **104**. Cephalic extremity, dorsal view. **105**. Submedian cephalic papilla, lateral view. **106**. Cephalic extremity, apical view. **107**. Cephalic extremity, transverse optical section through buccal capsule. **108**. Preneural region of oesophagus, showing denticle, lateral view, dorsal aspect on left-hand side. **109**. Preneural region of oesophagus, showing denticle, dorsal view. **110**. Spicule tips, ventral view. **111**. Bursa, ventral view. **112**. Bursa, lateral view. **113**. Female tail, lateral view. **114**. Female genital system, lateral view. **115**. Genital cone, dorsal view. Scale bars: 113, 114, 0.1 mm; 102–104, 106–112, 115 0.01 mm; 105, 0.003 mm.

prominent lips and unornamented oesophagus with a single dorsal denticle differentiate *C. papuensis* sp. nov. from all congeners except *C. cornuta*, *C. dirce*, *C. longispiculata* and *C. sciron*. *C. papuensis* is differentiated from *C. sciron* primarily in having the deirid anterior to, rather than at the level of, the nerve ring. In *C. sciron*, the anterior margin of the buccal capsule arches anteriorly and is sinuous. *C. papuensis* differs from *C. longispiculata* in lacking the prominent shoulder-like inflations of the cervical cuticle, in having the excretory pore at the level of the oesophago-intestinal junction rather than well posterior to it as in *C. longispiculata*, and in having eight leaf crown elements rather than the six present in *C. longispiculata*. It differs from *C. dirce* in lacking the prominent cervical inflation of the cuticle, in the shape of the submedian papillae which have an extended distal segment in *C. dirce*, in spicule lengths (1.84–2.26 (2.05) mm long in *C. papuensis*, 3.48–3.95 (3.70) mm long in *C. dirce*), and in the shape of the vagina which is longer and more convoluted in *C. dirce*. Therefore, *C. papuensis* most closely resembles *C. cornuta*, also a parasite of *Macropus agilis*, in having a prominent dorsal oesophageal tooth. It differs from *C. cornuta* in lacking a cervical cuticular inflation, in the shape of the submedian papillae which have elongate distal segments in *C. cornuta*, in the shape of the dorsal ray which in *C. cornuta* terminates in very short subequal internal and external branchlets, in spicule length (1.84–2.26 (2.05) in *C. papuensis*, 1.38–1.62 (1.51) mm in *C. cornuta)*, and in the length and shape of the female tail which is very short and prominently swollen in *C. cornuta*.

Cloacina polymela sp. nov.
(Figs 116–128)

Types: From stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May, 1987. Holotype ♂, SAM AHC 31454; allotype ♀, SAM AHC 31455. Paratypes: 4♂, 8♀, SAM AHC 31456, 1♂, 1♀, BMNH 2001.4.10.10–11, 1♂, 1♀, USNPC 91138. Slide preparations of apical views of mouth and bursa, SAM AHC 28387.

Material examined: From *Dorcopsis hageni:* types.

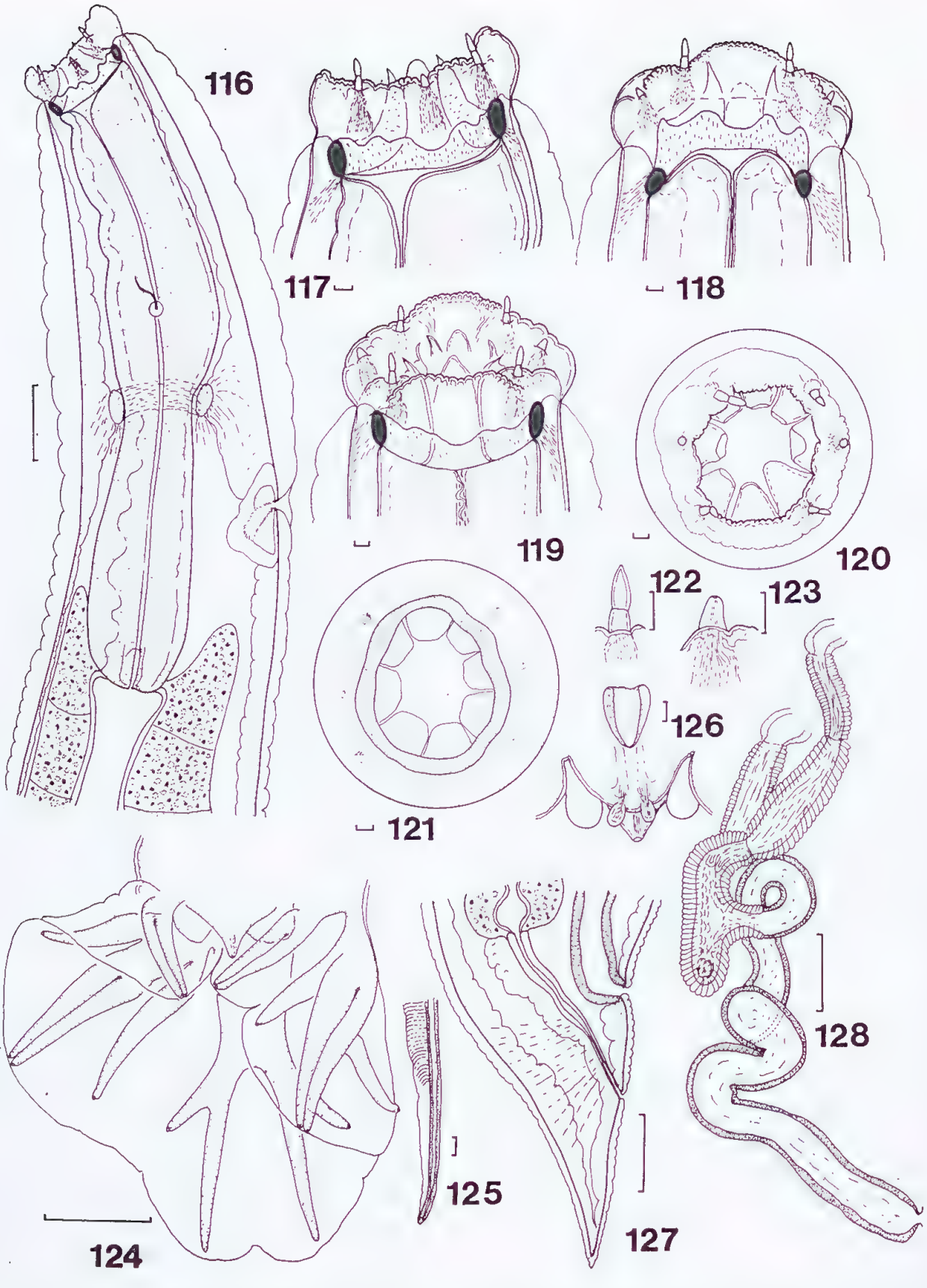
Description

Robust nematodes; anterior extremity deviated dorsally; cervical cuticle inflated to level of excretory pore; transverse cuticular annulations widely spaced, 0.030–0.062 apart. Submedian cephalic papillae prominent, 0.016 long, projecting anteriorly from inflated peri-oral cuticle; distal segment acute, conical, 0.010 long, longer than cylindrical proximal segment, 0.006 long. Cephalic collar prominently inflated on dorsal and ventral aspects, anterior margin of collar rugose; amphids conical, projecting above level of cephalic collar. Buccal capsule very shallow, symmetrical, anterior margin highly sinuous; due to dorsal deviation of anterior extremity, buccal capsule appears to arch dorsally in ventral views; oval and dorso-ventrally elongate in transverse section, wider than deep, wall finely striated. Leaf crown elements 8 in number, recurved at tips; peri-oral cuticle inflated into lip-like lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus claviform, robust, anterior section of greater diameter than region posterior to nerve ring; lining without sclerotised bosses; denticles absent in preneural region. Nerve ring posterior to mid point of oesophagus; deirids slightly anterior to level of nerve ring; excretory pore between nerve ring and oesophago-intestinal junction.

Male. Measurements of 9 specimens, types. Total length 5.86–6.03 (5.93); maximum width 0.29–0.46 (0.39); buccal capsule 0.020–0.030 (0.025) x 0.115–0.150 (0.130); oesophagus 0.66–0.79 (0.72); nerve ring to anterior end 0.44–0.53 (0.48); excretory pore to anterior end 0.55–0.70 (0.65); deirid to anterior end 0.36–0.45 (0.39); spicules 2.61–2.71 (2.65); gubernaculum 0.035–0.050 (0.045) long.

Dorsal ray broad at origin; major bifurcation occurs at 1/2 length; angle of bifurcation acute; external branchlets arise after major bifurcation, much shorter than internals, directed postero-laterally, not reaching margin of bursa; internal branchlets elongate, directed posteriorly, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, subcordate. Spicule tip blunt, slightly recurved; ala diminishes gradually in width towards spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Measurements of 10 specimens, types. Total length 5.45–8.22 (7.14); maximum width 0.33–0.59 (0.46); buccal capsule 0.015–0.030 (0.025) x 0.120–0.160 (0.150); oesophagus 0.70–



FIGURES 116–128. *Cloacina polymela* sp. nov., types. **116**. Anterior end, lateral view, showing dorsal deviation of head. **117**. Cephalic extremity, lateral view, dorsal aspect on left-hand side. **118**. Cephalic extremity, ventral view. **119**. Cephalic extremity, dorsal view. **120**. Cephalic extremity, apical view. **121**. Cephalic extremity, transverse optical section through buccal capsule. **122**. Submedian cephalic papilla, lateral view. **123**. Amphid, lateral view. **124**. Bursa, ventral view. **125**. Spicule tip, ventral view. **126**. Gubernaculum and genital cone, dorsal view. **127**. Female tail, lateral view. **128**. Female genital system, lateral view. Scale bars: 116, 124, 127, 128, 0.1 mm; 117–123, 125, 126, 0.01 mm.

0.94 (0.82); nerve ring to anterior end 0.45–0.61 (0.54); excretory pore to anterior end 0.55–0.85 (0.75); deirid to anterior end 0.31–0.50 (0.42); tail 0.21–0.30 (0.24); vulva to posterior end 0.33–0.50 (0.38); vagina 0.49–0.68 (0.60); egg 0.080–0.085 (0.082) x 0.040–0.045 (0.042).

Female tail slender, conical; vulva immediately anterior to anus; vagina elongate, sinuous, extends slightly anterior to vestibule with short recurrent section; egg ellipsoidal.

Remarks

Cloacina polymela sp. nov. is a highly distinctive species which differs from all congeners in having the anterior extremity deviated dorsally. This feature appears in every specimen and therefore is not likely to be a fixation artefact. In addition, it differs from congeners except *C. dryope* Beveridge, 1998 and *C. sappho* in having an oesophagus in which the preneural region is of greater diameter than the posterior part. *C. polymela* is distinguished from *C. dryope* in having eight rather than six leaf crown elements, in having a more posterior deirid, in having the excretory pore anterior to the oesophago-intestinal junction rather than posterior to it, and in the shape of the buccal capsule which is extremely shallow in *C. dryope* and in which the anterior margin has only slight saliences rather than prominent undulations. *C. polymela* and *C. sappho* are the only two members of the genus in which the amphids form acutely pointed conical projections above the cephalic collar. In all other species, the amphids are dome-shaped and do not project obviously beyond the collar. *C. polymela* also resembles *C. sappho* in the shape of the dorsal ray of the bursa and in possessing eight leaf crown elements. However, it differs in having prominent inflations of the cephalic collar on the dorsal and ventral surface, a feature which resembles the lip-like projections present in *C. nephele*. *C. polymela* also differs from *C. sappho* in spicule length (2.61–2.71 (2.65) mm in *C. polymela*; 1.30–1.50 (1.38) mm in *C. sappho*) and in the shape of the vagina which is recurrent in *C. polymela* but short and straight in *C. sappho*.

Cloacina praxithea sp. nov.
(Figs 129–138)

Types: From stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May, 1987. Holotype ♂, SAM AHC 31457. Paratypes: 2♂, SAM AHC 31458, 1♂, BMNH 2001.4.10.12; 1♂, USNPC 91139. Slide preparations of apical views of mouth and bursa, SAM AHC 28388.

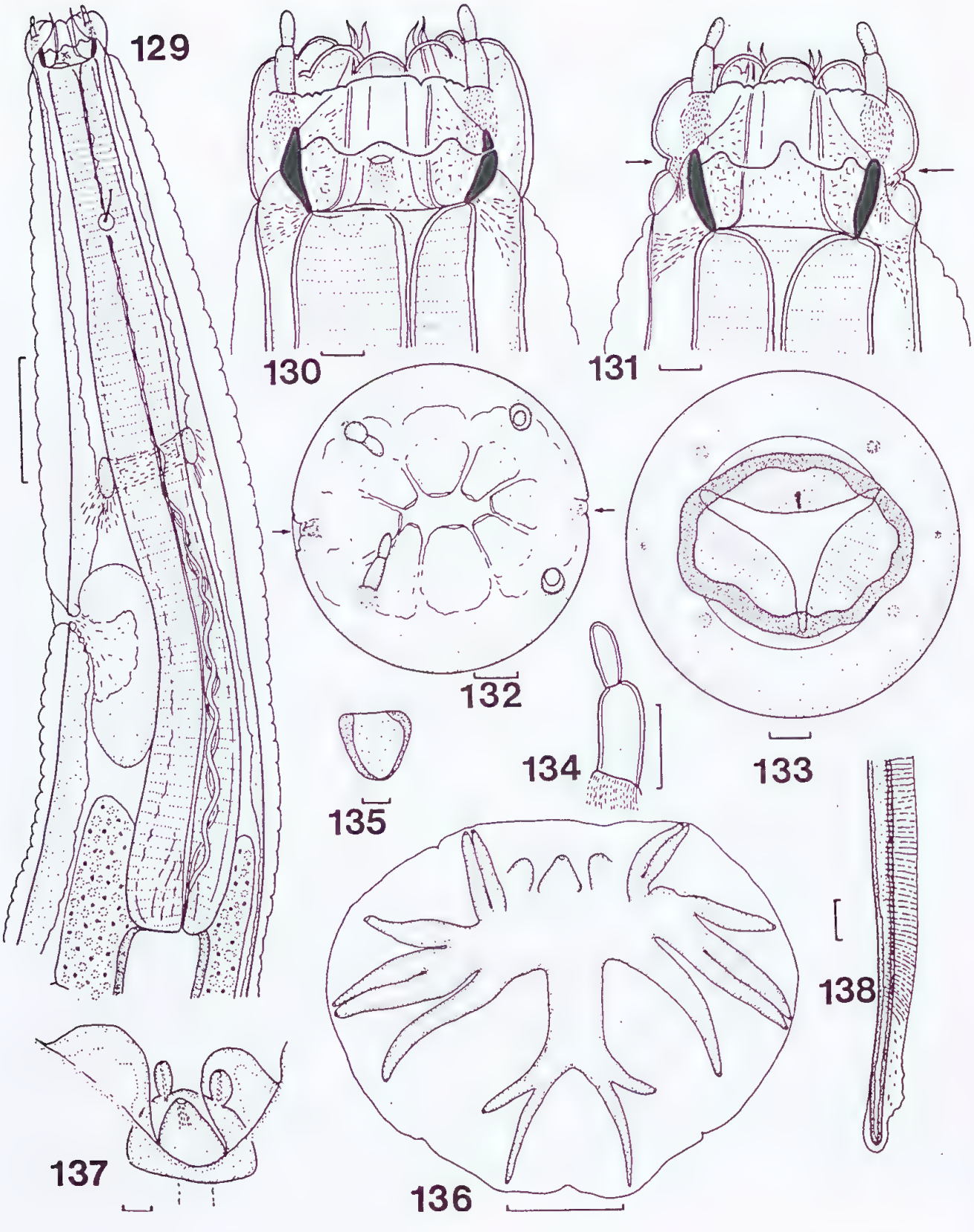
Material examined: From *Dorcopsis hageni:* types.

Description

Robust nematodes; cervical cuticle slightly inflated to beyond level of excretory pore; transverse cuticular annulations widely spaced, 0.015 apart. Submedian cephalic papillae prominent, 0.019 long, projecting anteriorly from peri-oral cuticle; distal segment ovoid, 0.008 long, deviated medially, slightly shorter than asymmetrical, cylindrical proximal segment, 0.011 long; submedian papillae situated anteriorly on cephalic collar; amphids situated posteriorly, below anterior margin of buccal capsule in lateral views. Buccal capsule shallow, symmetrical in lateral and dorso-ventral views, wall with faint striations; anterior margin undulate, with anterior projections associated with each leaf crown element. Leaf crown elements 8 in number, not recurved at tips; peri-oral cuticle inflated into lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus subcylindrical, almost claviform at base, robust; lining without sclerotised bosses or denticles; preneural swelling of oesophagus absent. Nerve ring in mid-oesophageal region; deirids anterior to nerve ring; excretory pore at level of, or slightly anterior to, oesophago-intestinal junction.

Male. Measurements of 6 specimens, types. Total length 3.71–5.34 (4.86); maximum width 0.32–0.38 (0.36); buccal capsule 0.015–0.018 (0.016) x 0.050–0.055 (0.054); oesophagus 0.66–0.78 (0.71); nerve ring to anterior end 0.34–0.38 (0.36); excretory pore to anterior end 0.43–0.49 (0.46); deirid to anterior end 0.27–0.32 (0.30); spicules 1.30–1.58 (1.43); gubernaculum 0.030–0.040 (0.033) long.

Dorsal ray broad at origin; major bifurcation occurs at 1/2 length; angle of bifurcation acute; external branchlets arise immediately after major bifurcation, much shorter than internals, directed postero-laterally, not reaching margin of bursa; internal branchlets directed posteriorly, not reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, subcordate, slightly wider than long. Spicule tip blunt; ala diminishes gradually in width then terminates abruptly anterior to spicule tip; anterior lip of genital cone conical; posterior



FIGURES 129–138. *Cloacina praxithea* sp. nov., types. **129**. Anterior end, lateral view. **130**. Cephalic extremity, lateral view, dorsal aspect on right-hand side. **131**. Cephalic extremity, dorsal view; arrows indicate amphids. **132**. Cephalic extremity, apical view; arrows indicate amphids. **133**. Cephalic extremity, transverse optical section through buccal capsule. **134**. Submedian cephalic papilla, lateral view. **135**. Gubernaculum, ventral view. **136**. Bursa, apical view. **137**. Genital cone, dorsal view. **138**. Spicule tip, lateral view. Scale bars: 129, 136, 0.1 mm; 130–135, 137, 138, 0.01 mm.

lip with paired projections and cuticular inflation of internal surface of bursa on either side.

Female. Not seen

Remarks

Cloacina praxithea sp. nov. is distinguished from all congeners by the position of the amphids on the cephalic collar. In other species the amphids are at the same level as the submedian papillae, anterior to the level of the buccal capsule, while in *C. praxithea* the amphids, in lateral view, are below the level of the anterior margin of the buccal capsule (Fig. 130). *C. parxithea* is characterised by a symmetrical, lobed buccal capsule without bosses or denticles in the oesophagus. As such, it has similarities with the Australian species *C. artemis*, *C. dryope*, *C. hebe*, *C. hypsipyle*, *C. linstowi*, *C. maia*, *C. thetidis* and *C. wallabiae*, all of which differ from it in having six rather than eight leaf crown elements. Among the species known from New Guinea, the features of the buccal capsule, as well as the presence of eight leaf crown elements, indicate affinities with *C. syphax*, *C. solon*, *C. sappho* and *C. solymus*. *C. solymus* has tiny cephalic papillae, in striking contrast to the prominent papillae of *C. praxithea*, while *C. sappho* and *C. polymela* have the amphids on or forming projections beyond the level of the cephalic collar; *C. solon* has a greatly inflated cervical cuticle and its spicules are 2.60–2.95 (2.81) mm in length compared with 1.93–2.05 (1.99) mm in *C. praxithea*; *C. syphax* differs in having the lateral branchlets of the dorsal ray arise anterior to the principal bifurcation. Therefore, *C. praxithea* is readily distinguishable from all congeners even in the absence of females, which are currently unknown.

Cloacina procris sp. nov.
(Figs 139–153)

Types: From stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May, 1987. Holotype ♂, SAM AHC 31459; allotype ♀, SAM AHC 31460. Paratypes: 1♂, 2♀, SAM AHC 31461. Slide preparations of apical views of mouth and bursa, SAM AHC 28389.

Material examined: From *Dorcopsis hageni:* types.

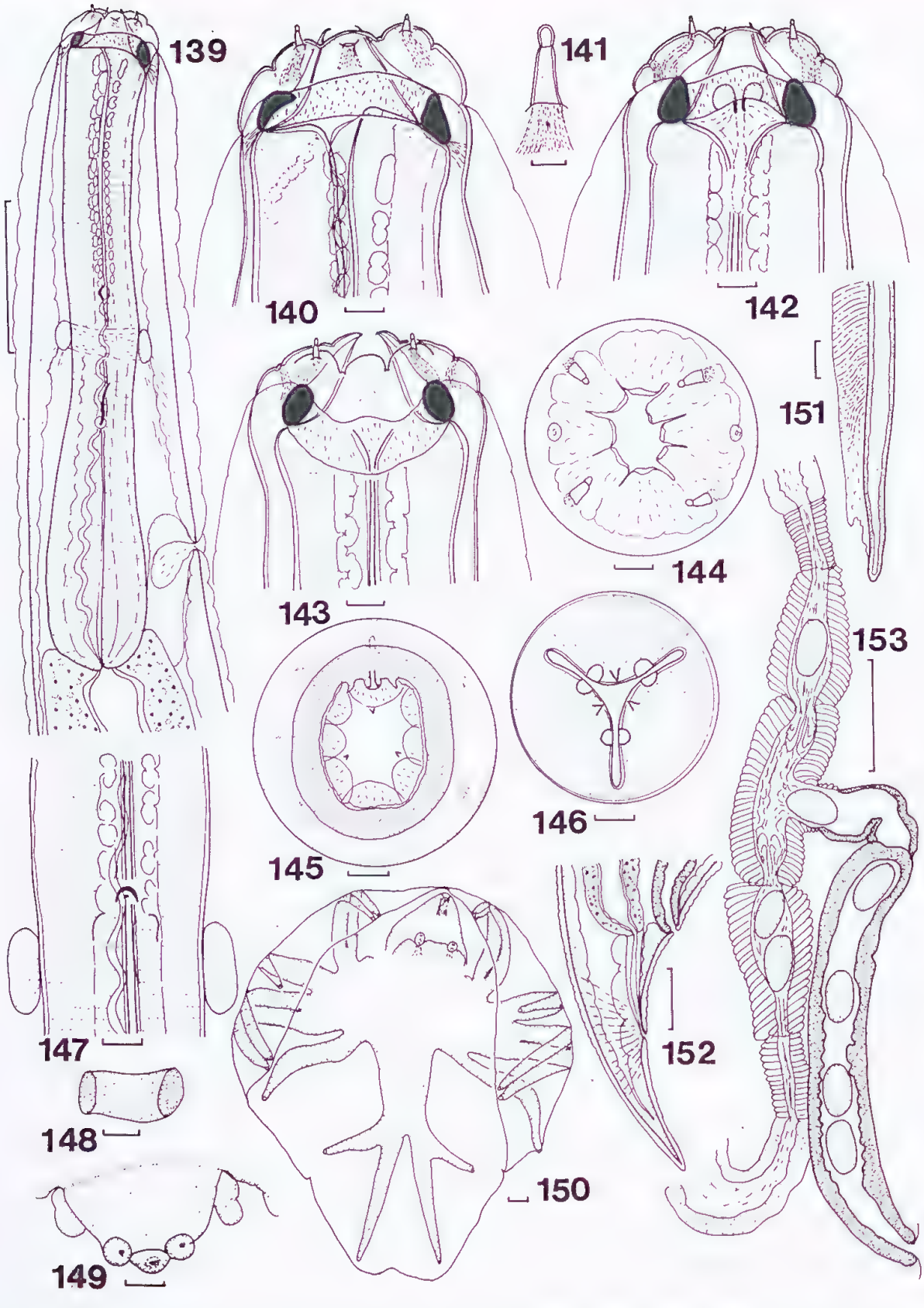
Description

Robust nematodes; cervical cuticle slightly inflated to level of excretory pore; transverse cuticular annulations widely spaced, 0.020 apart. Submedian cephalic papillae small, 0.0035 long, projecting anteriorly from peri-oral cuticle; distal segment ovoid, 0.0005 long, much shorter than cylindrical proximal segment, 0.003 long. Buccal capsule shallow, asymmetrical in lateral views, deeper on ventral side, slight anterior arching of capsule; dorsally, capsule arches anteriorly over dorsal oesophageal tooth; ventrally, curves posteriorly; oval and dorso-ventrally elongate in transverse section, wider than deep, wall with faint striations; anterior margin smooth. Leaf crown elements 8 in number, not recurved at tips; peri-oral cuticle very slightly inflated into lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, projecting prominently into lumen of buccal capsule; each sector of oesophagus bears single triangular tooth-like structure projecting into lumen. Oesophagus claviform, robust; lining with sclerotised bosses extending to level of nerve ring; single dorsal oesophageal denticle present in preneural region; preneural swelling of oesophagus absent. Nerve ring in mid-oesophageal region; deirids posterior to nerve ring; excretory pore at level of, or slightly anterior to, oesophago-intestinal junction.

Male. Measurements of 3 specimens, types. Total length 3.25–4.52 (3.89); maximum width 0.17–0.32 (0.26); buccal capsule 0.015–0.018 (0.017) x 0.050–0.060 (0.054); oesophagus 0.40–0.41 (0.40); nerve ring to anterior end 0.20–0.21 (0.21); excretory pore to anterior end 0.35–0.40 (0.38); deirid to anterior end 0.27–0.32 (0.30); spicules 1.30–1.58 (1.43); gubernaculum 0.030 (0.030) long.

Dorsal lobe of bursa elongate; dorsal ray broad at origin; major bifurcation occurs at 1/2 length; angle of bifurcation acute; external branchlets arise at level of major bifurcation, much shorter than internals, directed almost laterally, not reaching margin of bursa; internal branchlets directed posteriorly, reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, slightly wider than long. Spicule tip blunt; ala diminishes gradually in width then terminates abruptly anterior to spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflations of internal surface of bursa on either side.

Female. Measurements of 3 specimens, types. Total length 4.26–5.15 (4.64); maximum width 0.37–0.47 (0.42); buccal capsule 0.018–0.020 (0.019) x 0.060–0.065 (0.062); oesophagus



FIGURES 139–153. *Cloacina procris* sp. nov., types. **139**. Anterior end, lateral view. **140**. Cephalic extremity, lateral view, dorsal aspect on left-hand side. **141**. Submedian cephalic papilla, lateral view. **142**. Cephalic extremity, dorsal view. **143**. Cephalic extremity, ventral view. **144**. Cephalic extremity, apical view. **145**. Cephalic extremity, transverse optical section through buccal capsule. **146**. Transverse optical section through anterior extremity of oesophagus showing bosses and three tooth-like projections in each of the oesophageal sectors. **147**. Preneural region of oesophagus, dorsal view, showing denticle. **148**. Gubernaculum, ventral view. **149**. Genital cone, dorsal view. **150**. Bursa, apical view. **151**. Spicule tip, lateral view. **152**. Female tail, lateral view. **153**. Female genital system, lateral view. Scale bars: 139, 152, 153, 0.1 mm; 140, 142–151, 0.01 mm; 141, 2.5 μm.

0.48–0.50 (0.49); nerve ring to anterior end 0.21–0.22 (0.22); excretory pore to anterior end 0.36–0.40 (0.38); deirid to anterior end 0.29–0.33 (0.31); tail 0.19–0.27 (0.23); vulva to posterior end 0.35–0.47 (0.40); vagina 0.52–0.60 (0.53); egg 0.050–0.060 (0.055) x 0.030–0.035 (0.032).

Female tail slender, conical; vulva immediately anterior to anus; vagina elongate, straight, turns abruptly at entry to vestibule; egg ellipsoidal.

Remarks

Although described from only a small series of specimens, *C. procris* sp. nov. is quite distinctive morphologically. It is characterised by very small submedian cephalic papillae, a slightly asymmetrical, arched buccal capsule, eight leaf crown elements, bosses lining the anterior region of the oesophagus, a single, small oesophageal denticle, deirid posterior to the nerve ring, an elongate dorsal ray with the external branchlets arising immediately after the principal bifurcation, and a straight vagina. These features distinguish the species from all congeners.

The asymmetrical buccal capsule, oesophageal bosses and dorsal denticle with the posterior position of the deirid distinguish the species from all others except *C. eos* Beveridge, 1998, *C. papillata* Beveridge, 1979 and *C. sterope*. In *C. eos* and *C. papillata* there are only six rather than eight leaf crown elements and the vagina is prominently recurrent. In *C. sterope*, the buccal capsule exhibits a much greater degree of asymmetry, the submedian cephalic papillae are larger and more prominent and the spicules are longer (1.67–2.07 (1.96) mm in *C. sterope*, 1.30–1.58 (1.43) mm in *C. procris*).

Cloacina sterope Beveridge & Speare, 1999

Material examined: 3♂, 4♀, from stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May, 1987, SAM AHC 31462.

Remarks

Cloacina sterope was described by Beveridge and Speare (1999) from *Dorcopsulus vanhearni* from the Chimbu Province of New Guinea. Morphological features as well as measurements of the new specimens from *D. hageni* agree well with the original description. *D. hageni* represents a new host record.

Cloacina syphax Beveridge & Speare, 1999

Material examined: 17♂, 9♀, from stomach of *Dorcopsis hageni*, Usino, Madang, Papua New Guinea, coll. T. Reardon, May, 1987, SAM AHC 31469; BMNH 2001.4.10.13.

Remarks

Cloacina syphax was described from *Dorcopsulus vanheurni* by Beveridge and Speare (1999). The current collection represents a new host record.

Cloacina theope sp. nov.

(Figs 154–166)

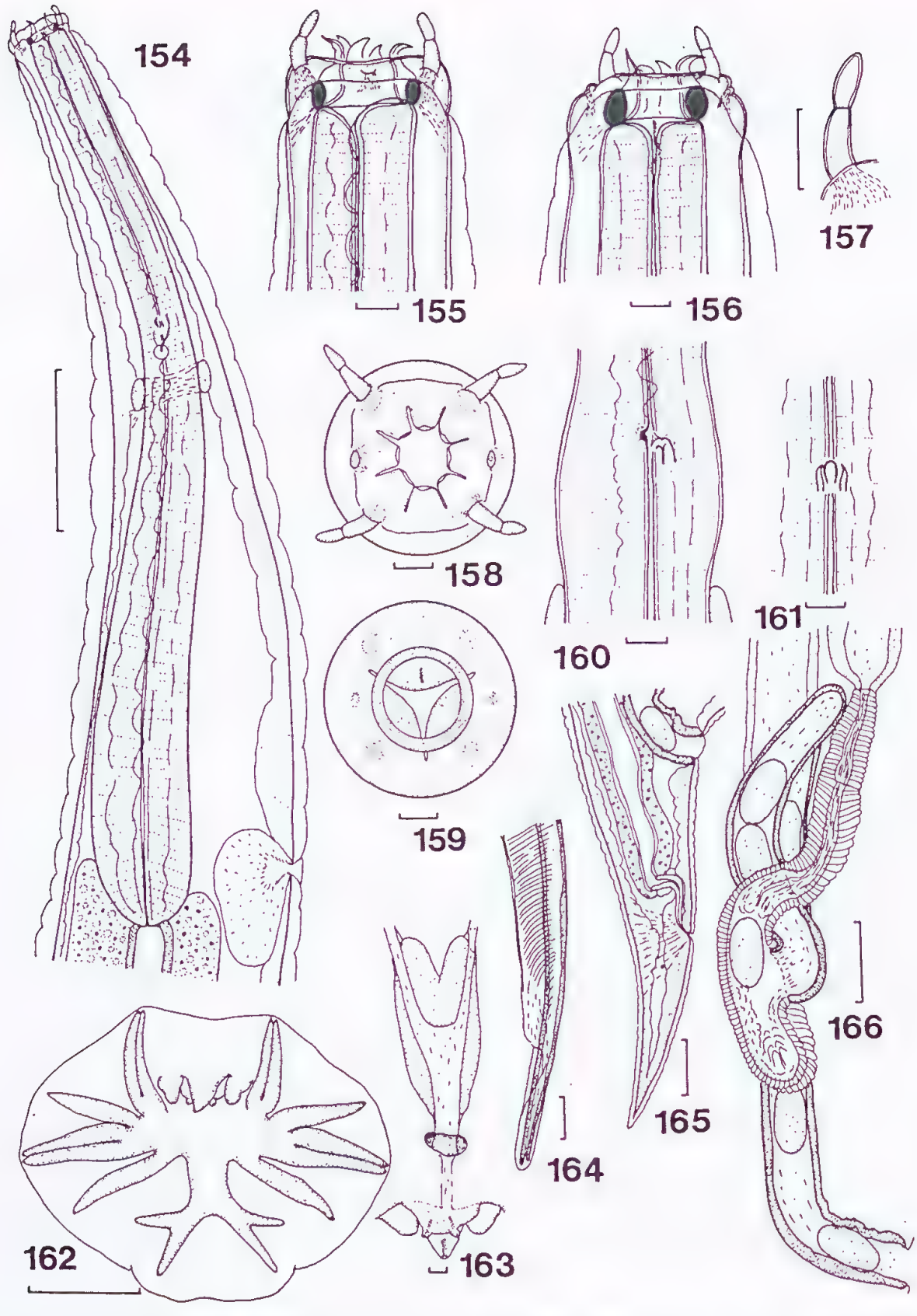
Types: From stomach of *Dendrolagus matschiei* Forster & Rothschild, 1907, Huon Peninsula, Morobe Province, Papua New Guinea, coll. J. Mayer, July 1999. Holotype ♂, USNPC 91140; allotype ♀, USNPC 91141. Paratypes: 2♂, 4♀, USNPC 91142; 1♂, on slides, SAM AHC 28390.

Material examined: From *Dendrolagus matschiei:* types. From *Dendrolagus dorianus*: 10♂, 5♀, Lake Trist, Papua New Guinea, coll. I. Redmond, 1979, BMNH 1981. 4486–4505.

Description

Robust nematodes; cervical cuticle slightly inflated; transverse cuticular annulations widely spaced, 0.021–0.044 apart. Submedian cephalic papillae prominent, 0.017 long, projecting anteriorly from inflated peri-oral cuticle; distal segment ovoid, 0.008 long, directed slightly medially, slightly shorter than robust, asymmetrical proximal segment, 0.009 long. Buccal capsule shallow, symmetrical in lateral and dorso-ventral views; circular in transverse section, wall without prominent striations; anterior margin smooth. Leaf crown elements 8 in number, recurved at tips; peri-oral cuticle not inflated into lip-like lobes attached to each element. Dorsal sector of oesophagus bearing opening of dorsal oesophageal gland, not projecting into lumen of buccal capsule. Oesophagus claviform, slender; lining without sclerotised bosses; denticles present in preneural region; dorsal denticle prominent; two subventral thickenings of oesophageal lining giving appearance of denticles, at same level as dorsal denticle. Nerve ring in mid-oesophageal region; deirids at level of nerve ring; excretory pore at level of oesophago-intestinal junction.

Male. Measurements of 4 specimens, types. Total length 4.68–5.04 (4.88); maximum width



FIGURES 154–166. *Cloacina theope* sp. nov., types. **154**. Anterior end, lateral view. **155**. Cephalic extremity, lateral view, dorsal aspect on left-hand side. **156**. Cephalic extremity, dorsal view. **157**. Submedian cephalic papilla, lateral view. **158**. Cephalic extremity, apical view. **159**. Cephalic extremity, transverse optical section through buccal capsule. **160**. Preneural region of oesophagus, lateral view, dorsal aspect on left-hand side, showing denticles. **161**. Preneural region of oesophagus, dorsal view, showing denticles. **162**. Bursa, apical view. **163**. Gubernaculum, genital cone and spicule sheaths, dorsal view. **164**. Spicule tip, lateral view. **165**. Female tail, lateral view. **166**. Female genital system, lateral view. Scale bars: 154, 162, 165, 166, 0.1 mm; 155–161, 163–164, 0.01 mm.

0.30–0.32 (0.31); buccal capsule 0.010 (0.010) x 0.030–0.033 (0.031); oesophagus 0.51–0.60 (0.55); nerve ring to anterior end 0.18–0.20 (0.19); excretory pore to anterior end 0.31–0.41 (0.35); deirid to anterior end 0.13–0.23 (0.18); spicules 2.29–2.63 (2.52); gubernaculum 0.015–0.020 (0.018) long.

Dorsal ray broad at origin; major bifurcation occurs at 1/2 length; angle of bifurcation obtuse; external branchlets arise immediately after major bifurcation, shorter than internals, directed laterally, not reaching margin of bursa; internal branchlets directed postero-laterally, almost reaching margin of bursa. Externo-dorsal ray not reaching margin of bursa. Gubernaculum prominent, slightly wider than long. Spicule tip minutely bifid; ala diminishes gradually in width towards spicule tip; anterior lip of genital cone conical; posterior lip with paired projections and cuticular inflations of internal surface of bursa on either side.

Female. Measurements of 5 specimens, types. Total length 6.09–6.71 (6.29); maximum width 0.39–0.43 (0.41); buccal capsule 0.008–0.010 (0.009) x 0.030–0.035 (0.032); oesophagus 0.52–0.64 (0.59); nerve ring to anterior end 0.25 (0.25); excretory pore to anterior end 0.30–0.51 (0.43); deirid to anterior end 0.14–0.23 (0.20); tail 0.28–0.36 (0.33); vulva to posterior end 0.49–0.68 (0.59); vagina 1.03–1.33 (1.19); egg 0.085–0.095 (0.089) x 0.045–0.050 (0.048).

Female tail slender, conical; vulva immediately anterior to anus; vagina elongate, sinuous, extends slightly anterior to vestibule with short recurrent section; egg ellipsoidal.

Remarks

Cloacina theope sp. nov. differs from congeners in having three oesophageal denticles in the preneural region of the oesophagus which are at the same level, but are of dissimilar sizes. The dorsal denticle is well developed but the subventral denticles are mere thickenings of the oesophageal lining and may not warrant the designation as denticles. In all other species with three denticles at the same level in the oesophagus, *C. daveyi*, *C. eurynome*, *C. hera*, *C. hermes*, *C. hestia*, the denticles are equally developed, although in *C. hestia* and *C. eurynome* all three denticles may be weakly sclerotised. *C. theope* differs from *C. daveyi*, which has submedian cephalic papillae in which the distal segment is large and directed medially, and from all the remaining species, which have the deirid in the anterior oesophageal position and six rather than eight leaf crown elements. It is most similar to *C. eurynome* from which it differs principally in having shorter spicules (3.57–3.98 (3.77) mm in *C. eurynome*, 2.29–2.63 (2.52) mm in *C. theope*).

If the subventral denticles are excluded from consideration, then the unornamented anterior oesophagus, a symmetrical buccal capsule with a smooth anterior margin, and the presence of a dorsal denticle indicates similarities with *C. cornuta*, *C. dindymene*, *C. dirce*, *C. ernabella*, *C. longispiculata* and *C. sciron*. *C. ernabella* differs in the shape of the cephalic papillae (globose, medially directed distal segment in *C. ernabella*), while all species except *C. sciron* differ in having the deirid in the anterior oesophageal region rather than at the level of the nerve ring. *C. theope* differs from *C. sciron,* which has an anteriorly arched buccal capsule, longer spicules (2.83–3.30 (3.00) mm in *C. sciron*, 2.29–2.63 (2.52) mm in *C. theope*), a longer dorsal ray and a vagina which is not recurrent. In *C. theope* the recurrent section of the vagina is twisted around the ascending arm in a manner similar to that found in *C. syphax* and *C. eurynome*. *C. theope* differs from *C. syphax* in the shape of the buccal capsule, which has an undulating anterior margin in *C. syphax* but is straight in *C. theope*. Therefore, *C. theope* is clearly distinguishable from all congeners.

Discussion

The new records and new species reported in this paper suggest that a diverse array of species of *Cloacina* exists in macropodid marsupials in Papua New Guinea. Conclusions need to be guarded as the current collections have been obtained from a small number of individuals of each host species, in some instances from a single animal. As yet, there have been no comprehensive surveys of New Guinean macropodids for parasites, and several species of *Thylogale, Dorcopsis, Dorcopsulus* and *Dendrolagus* have apparently yet to be examined for helminths (Spratt *et al.* 1991). In addition, Beveridge (1998) and Beveridge and Speare (1999) have listed museum records of additional undescribed species from some of these hosts which cannot currently be named due to lack of adequate material.

In spite of the relatively rudimentary knowledge of the New Guinean parasite fauna, some preliminary comparisons can be made with species present in Australia. In terms of morphological characters, the species of *Cloacina* present in New

Guinea are virtually as diverse as those present in Australia. Of the various morphological features of the genus, only the spiral twisting of the proximal, recurrent region of the vagina (*C. syphax, C. eurynome, C. theope*) and the presence of amphids on conical projections (*C. praxithea, C. sappho*) appear to be restricted to species from New Guinea. Two other apparently autapomorphic characters, using *Arundelia dissimilis* (Johnston & Mawson, 1939) as an outgroup, are the posterior position of the amphids in *C. praxithea* and the dorsal deviation of the head in *C. polymela*. *A. dissimilis* is the sole member of a closely related genus within the tribe Cloacininea (see Beveridge 1987) and is therefore considered to be an appropriate outgroup for polarising morphological characters. Characters such as the origin of the external branchlets of the dorsal ray anterior to the major bifurcation are more common in species from New Guinea, but are also found in species from northern Australia. No obvious patterns are detectable in the distribution of other characters. While only tentative conclusions can be drawn in the absence of a formal phylogenetic analysis, there do not appear to be any major distinctions which can be drawn between species occurring in New Guinea compared with those present in Australia.

In several instances (*C. australis, C. cloelia, C. cornuta, C. cybele, C. dahli*), the same species of *Cloacina* are found in Australia and in New Guinea, a phenomenon explicable in terms of host distribution. *C. australis* and *C. cornuta* are both parasites of *M. agilis*, a wallaby which is common in northern Australia (Strahan 1995) and which invaded southern New Guinea relatively recently from Australia (Flannery 1995). Similarly, *C. cloelia, C. cybele* and *C. dahli* occur in pademelons of the genus *Thylogale*, and at least one species, *T. stigmatica*, is thought to be a recent arrival in New Guinea (Winter 1997). However, the occurrence of these same nematodes in species of *Thylogale* restricted to New Guinea suggests that they have been present for a longer period of time than the recent invasion of *T. stigmatica*.

The remaining species of *Cloacina* currently described from New Guinea occur in hosts which are endemic. Species of scrub wallabies *Dorcopsis* and *Dorcopsulus* do not occur in Australia, while the tree kangaroos, *Dendrolagus* spp., have apparently radiated in New Guinea and invaded north-eastern Australia secondarily (Flannery et al. 1996). The recent arrival of the genus *Dendrolagus* in Australia may have contributed to the absence of species of *Cloacina* in *D. lumholtzi* and *D. bennettianus*.

While the records of species of *Cloacina* from New Guinea are still fragmentary, it appears that a substantial New Guinean fauna exists, and its relationships with its hosts and the comparisons that can be made with Australian representatives may provide insights into the evolution and hence the diversity of this nematode genus.

Key to species of *Cloacina* in macropodids from Papua New Guinea

1. — Denticles present in preneural region of oesophageal lumen 2
   — Denticles absent 13
2. — Paired ventral oesophageal denticles anterior to dorsal denticle ..... *C. dahli*
   — Single dorsal denticle, or three denticles at same level in oesophagus 3
3. — Anterior part of oesophagus lined with sclerotised bosses 4
   — Anterior oesophagus without sclerotised bosses 8
4. — Anterior oesophageal bosses much larger than other bosses; deirid anterior to nerve ring; female tail swollen ..... *C. australis*
   — Oesophageal bosses of similar size; deirid at level of nerve ring or posterior to it; female tail not swollen 5
5. — Buccal capsule symmetrical in lateral view ..... *C. erigone*
   — Buccal capsule asymmetrical in lateral view, more shallow on dorsal aspect ... 6
6. — Buccal capsule prominently arched anteriorly ..... *C. hyperea*
   — Buccal capsule not prominently arched anteriorly 7
7. — Spicules 1.30–1.58 mm; distal segment of submedian papilla less than 1/4 length of proximal segment ..... *C. procris*
   — Spicules 1.67–2.07 mm; distal segment of submedian papilla only slightly shorter than proximal segment ..... *C. sterope*
8. — Dorsal denticle and 2 vestigial subventral denticles present 9
   — Single dorsal denticle present 10
9. — Spicules 3.57–3.98 mm ..... *C. eurynome*
   — Spicules 2.29–2.63 mm ..... *C. theope*
10. — Prominent lips present ..... *C. oweni*
    — Lips absent 11
11. — Deirid at level of nerve ring; anterior margin

of buccal capsule arched ..... *C. sciron*

— Deirid in anterior oesophageal region, anterior margin of buccal capsule horizontal 12

12. — Cervical cuticle and female tail inflated, distal segment of submedian papilla almost as long as proximal segment, spicules 1.38–1.62 mm ..... *C. cornuta*

— Cervical cuticle and female tail not inflated, distal segment of submedian cephalic papilla much shorter than proximal segment, spicules 1.84–2.26 mm ..... *C. papuensis*

13. — Anterior margin of buccal capsule undulate 14

— Anterior margin of buccal capsule not undulate 18

14. — Amphids on or forming conical elevations projecting beyond cephalic collar 15

— Amphids embedded within cephalic collar 16

15. — Head deviated dorsally, cephalic collar elevated between adjacent submedian papillae ..... *C. polymela*

— Head directed anteriorly, cephalic collar depressed between adjacent submedian papillae ..... *C. sappho*

16. — External branchlets of dorsal ray arise before major bifurcation ..... *C. syphax*

— External branchlets of dorsal ray arise after major bifurcation 17

17. — Cervical cuticle prominently inflated, submedian papillae project prominently beyond cephalic collar ..... *C. solon*

— Cervical cuticle not inflated, submedian papillae very small, barely project above cephalic collar ..... *C. solymus*

18. — External branchlets of dorsal ray arise before major bifurcation 19

— External branchlets of dorsal ray arise after major bifurcation 21

19. — Deirid anterior to nerve ring ..... *C. cunctabunda*

— Deirid posterior to nerve ring 20

20. — Spicule length 2.34–2.97 mm ..... *C. cretheis*

— Spicule length 1.23–1.45 mm ..... *C. caballeroi*

21. — Buccal capsule sinuous in apical views, appearing as extra thickenings of wall in lateral or dorso-ventral views ..... *C. sancus*

— Buccal capsule not sinuous in apical views 22

22. — Buccal capsule prominently arched anteriorly ..... *C. nephele*

— Buccal capsule not prominently arched 23

23. — Amphids posterior to anterior margin of buccal capsule ..... *C. praxithea*

— Amphids anterior to anterior margin of buccal capsule 24

24. — Oesophagus with sclerotised bosses, spicule tip foot-shaped ..... *C. cloelia*

— Oesophagus lacking bosses, spicule tip simple 25

25. — Spicule length 3.90–5.05 mm, spicule tip simple ..... *C. hecale*

— Spicule length 2.30–2.90 mm, spicule tip with enlarged flange, ala terminating abruptly anterior to spicule tip ..... *C. cybele*

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DARWIN FORMATION (EARLY CRETACEOUS, NORTHERN TERRITORY) MARINE REPTILE REMAINS IN THE SOUTH AUSTRALIAN MUSEUM

BENJAMIN P. KEAR

KEAR, B. P. 2002. Darwin Formation (Early Cretaceous, Northern Territory) marine reptile remains in the South Australian Museum. *Records of the South Australian Museum* 35(1): 33–47.

Marine reptile remains from Early Cretaceous (Aptian/Albian) deposits of the Darwin Formation, Northern Territory, are described from the collections of the South Australian Museum. The material includes vertebra and limb girdle elements from ichthyosaurs and plesiosauroids, as well as the first described pliosaurid remains from the Northern Territory. The pliosaurid specimen (a single femur) is attributed to the small-bodied (up to 3 m in length) freshwater/near-shore marine taxon *Leptocleidus*, supporting interpretation of the Darwin Formation as representing a near-shore marine depositional environment. A comparison of the Darwin Formation marine reptile fauna with those known from Early Cretaceous deposits elsewhere in Australia, indicates greatest compositional similarity to the Hauterivian–Barremian Birdrong Sandstone fauna of Western Australia. A potential link between the distribution of some marine reptile taxa (eg pliosaurids) and the prevailing depositional environment is also suggested.

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Sometime in the 1960s (exact date unknown), a small collection of fossil marine reptile remains from the Early Cretaceous (Aptian/Albian) deposits of Casuarina Beach, Darwin Formation, Northern Territory (see Murray 1987, Fig. 1, p. 95 for locality map) was donated to the South Australian Museum. In 1994 several additional Darwin Formation marine reptile specimens were acquired as part of an exchange with the Museum and Art Gallery of the Northern Territory. A recent examination of these remains, which include isolated elements from both ichthyosaurs and plesiosauroids, has also revealed the presence of a pliosaurid femur. This specimen is attributable to the genus *Leptocleidus* Andrews, 1922 and represents the first documented pliosaur material from the Northern Territory. This paper describes Darwin Formation marine reptile remains currently housed in the South Australian Museum and provides a brief palaeoecological analysis based on faunal comparison with other known Early Cretaceous marine reptile bearing deposits.

Marine reptile remains were first reported from the Darwin Formation by an anonymous author (1924) who described a fragmentary ichthyosaur skeleton from Fannie Bay near Darwin. This specimen was later attributed to *Ichthyosaurus australis* (Tiechert & Matheson 1944); however, Murray (1985) re-assigned the material, along with other ichthyosaur remains from Nightcliff, north of Fannie Bay, to Ichthyosauria gen. et sp. indet. A more recent examination by Wade (1990) suggested that all ichthyosaur material from the Darwin Formation might be synonymous with *Platypterygius longmani* from the Aptian–Albian of Queensland. Murray (1987) described isolated ichthyosaur and elasmosaurid remains from Casuarina Beach, assigning the material to *Platypterygius* sp. and Elasmosauridae gen. et sp. indet., respectively. The presence of elasmosaurid and pliosaurid remains in the Casuarina Beach deposits was also noted by Cruickshank et al. (1999) but no descriptions were provided.

A comparison of the Darwin Formation marine reptile fauna with those known from Early Cretaceous deltaic-marine deposits elsewhere in Australia (Wallumbilla Formation [Doncaster Member], Allaru Mudstone, Toolebuc Formation and Mackunda Formation, Queensland; Bulldog Shale, South Australia; Wallumbilla Formation [Doncaster Member], New South Wales; Birdrong Sandstone and Barrow Group, Western Australia) indicates greatest compositional similarity to the Hauterivian–Barremian Birdrong Sandstone fauna, with ichthyosaurs, elasmosaurids and the small-bodied pliosaurid *Leptocleidus* represented. A potential link between the distribution of some

marine reptile taxa (eg pliosaurids) and the prevailing depositional environment is also suggested. The presence of *Leptocleidus*, a pliosaurid genus known otherwise from freshwater and near-shore marine deposits (Andrews 1911, 1922; Strömer 1935; Cruickshank 1997; Cruickshank & Long 1997; Cruickshank et al. 1999) supports interpretation of the Darwin Formation as representing a shallow near-shore marine depositional environment (*sensu* Smart & Senior 1980; Murray 1985; Henderson 1998).

Materials And Methods

Institutional abbreviations used: SAM, South Australian Museum, Adelaide; NTM, Museum and Art Gallery of the Northern Territory, Darwin; AM, Australian Museum, Sydney.

Lithostratigraphic nomenclature follows Mory (1988) for Early Cretaceous deposits of the Darwin area and Burton & Mason (1998) for the opal-bearing sediments of White Cliffs, New South Wales. Systematic terminology follows Montani (1999) for Ichthyopterygia and Brown (1981) for Plesiosauria except in the subdivision of Pliosauroidea, in which Polycotylidae is retained as a separate family (*sensu* Williston 1925; White 1940; Persson 1963; Welles 1962; Carpenter 1996, 1997). Functional sub-division of the vertebral column in ichthyopterygians follows Buchholtz (2001), with designation of structural units as neck, trunk, tail stock and fluke. Interpretation of plesiosaur pelvic and femoral musculature follows Robinson (1975) and Lingham-Soliar (2000). All measurements were taken using callipers and are in millimetres (mm).

Geological Setting And Preservation

The marine reptile-bearing deposits of the Darwin Formation are typically characterised by glauconitic sandstone and radiolarian mudstone with basal quartzose conglomerate and localised nodular phosphorite horizons (Henderson 1998). The unit forms part of the Bathurst Island Group, which rests nonconformably on Precambrian basement within the Money Shoals Platform (see Fig. 1, p. 117 and Fig. 6, p. 124 of Henderson 1998 for locality and stratigraphic setting). At its base, the Bathurst Island Group is composed of the laterally equivalent Darwin Formation and Marligar Formation, which are overlain in turn by the Wangarlu Mudstone and Moonkinu Formation.

The Darwin Formation has historically been considered Albian in age on the basis of its macroinvertebrate (Day 1969; Skwarko 1966, 1968; Henderson 1990) and palynomorph (Morgan 1980) assemblages; however, more recent analyses (Henderson 1998; D. Megirian pers. comm. 2000) suggest an upper Aptian age. The Marligar Formation has been dated as Neocomian/Aptian by palynological studies (Burger 1978) and upper Aptian because of its laterally equivalent relationship with the Darwin Formation (Henderson 1998). The overlying Wangarlu Mudstone is regarded as upper Albian–Cenomanian (possibly with a basal lower Albian component, Henderson 1998) on the basis of ammonite (Henderson 1990) and palynological (Norvick & Burger 1975; Burger 1978) data. The uppermost Moonkinu Formation is considered Cenomanian–Turonian on account of its ammonite (Wright 1963) and bivalve/gastropod/scaphopod (Skwarko 1983) faunas.

The glauconitic sandstones and predominant radiolarian mudstones of the Darwin Formation reflect a near-shore marine/paralic depositional environment (Smart & Senior 1980; Henderson 1998). The presence of a limited benthic invertebrate fauna also suggests unfavourable, possibly anoxic bottom conditions (Henderson 1998).

The Darwin Formation marine reptile remains generally occur as heavily weathered isolated elements, although several fragmentary skeletons have been recovered (Murray 1985; D. Megirian pers. comm. 2000). The disarticulated nature of the remains led Murray (1985) to speculate that an inshore and/or tidal depositional environment may have facilitated stranding of decaying carcasses on mudflats prior to burial.

Systematics

DIAPSIDA Osborn, 1903

ICHTHYOPTERYGIA Owen, 1860

ICHTHYOSAURIA de Blainville, 1835

OPHTHALMOSAURIA Appleby, 1956 (*sensu* Montani 1999)

Platypterygius von Huene, 1922

cf. Platypterygius longmani

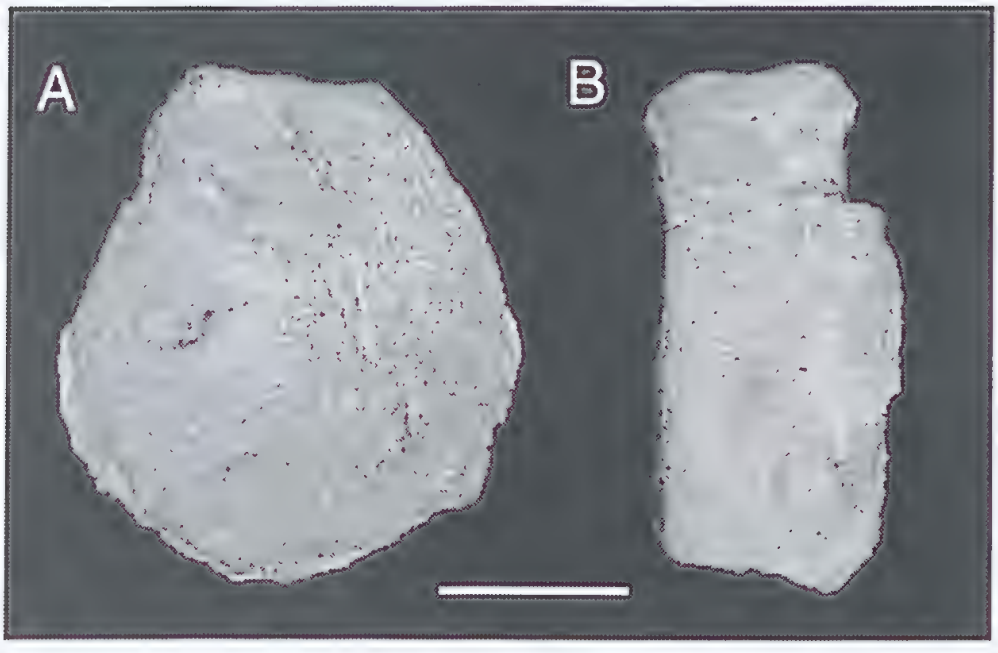

FIGURE 1. SAM P35039, *cf. Platpterygius longmani* dorsal vertebra in (A) anterior and (B) lateral views. Scale bar is 40 mm.

Material

SAM P35039 (Figs 1A, B; Table 1), four associated mid-posterior trunk vertebral centra; SAM P35426 (Table 1), two articulated anterior trunk centra; SAM P35427 (Table 1), three associated anterior tail stock centra; SAM P35429 (Table 1), two associated sections of eight and four articulated anterior? tail stock centra; SAM

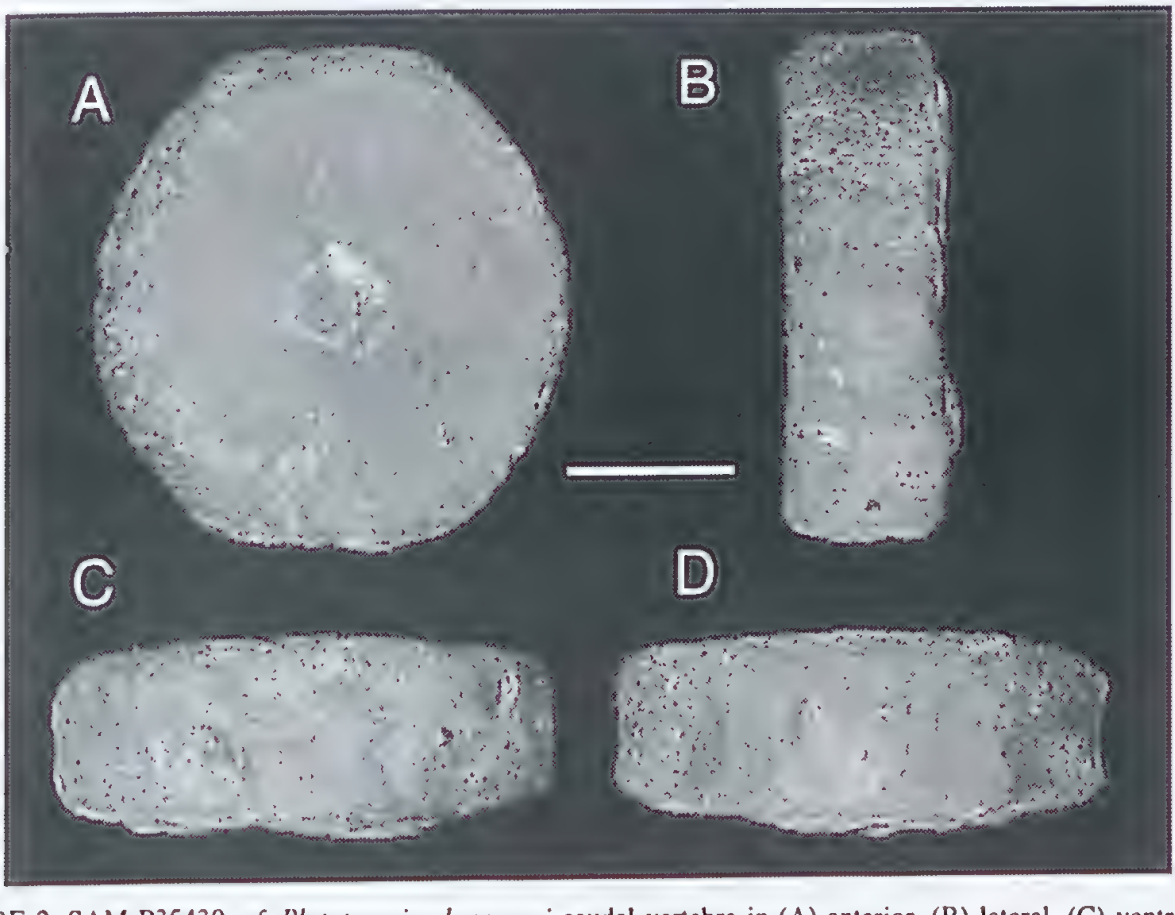

FIGURE 2. SAM P35430, *cf. Platpterygius longmani* caudal vertebra in (A) anterior, (B) lateral, (C) ventral and (D) dorsal views. Scale bar is 20 mm.

TABLE 1. Measurements (mm) of *cf. Platypterygius longmani* vertebral centra from the Darwin Formation, Northern Territory.

Specimen	Length	Width	Height
SAM P35039	39.6	91.2	98.9
	33.1	88.9	90.2
	30.2	80.1	89.2
	32.3	62.6	66.1
SAM P35426	40.6	85.5	88.9
	37.0	86.1	89.7
SAM P35427	40.7	94.0	96.4
	30.1	86.2	92.4
	25.8	102.8	109.6
*SAM P35429	24.9	81.6	69.9
	25.8	83.1	75.2
	26.4	86.4	79.1
	25.2	64.8	83.9
	20.5	–	78.2
	21.6	58.3	60.1
	21.1	58.9	50.8
	22.3	–	57.2
	17.4	–	55.1
	18.9	–	46.6
	14.1	–	46.9
	–	–	–
SAM P35430	20.8	68.9	59.7
	20.8	61.1	62.1
	18.7	55.7	56.1
	14.6	53.2	50.4
	15.3	47.9	48.3
	15.3	42.8	42.6
	15.2	43.6	45.0
	12.9	41.5	41.3

* some centra represented by fragments only

P35430 (Figs 2A, B, C, D; Table 1), nine associated anterior tail stock centra (juvenile).

Locality

Casuarina Beach, north of Darwin, Northern Territory. Darwin Formation, Aptian or Albian.

Description

All of the preserved centra are disc-like and anteroposteriorly compressed, with the dorsal length subequal to the ventral. Tail stock centra (Figs 2A, B, C, D) exhibit a more marked degree of anteroposterior compression relative to those from the trunk region (Figs 1A, B) and are slightly ovoid in outline, with height being approximately 1.5 times the transverse width. The articular surfaces of all centra are deeply amphicoelous, with a distinct central notochordal pit. The neural canal is generally broad and shallow, becoming narrower in centra from the tail stock region. The neural arch facets are narrow and rectangular in all centra. Where preserved, both the diapophyses and parapophyses of the trunk centra are distinctly raised and subcircular. This is unlike centra from the tail stock region, in which only the ovoid diapophysis is present and positioned low on the lateral centrum surface. The ventral surfaces of at least two of the recovered centra from the tail stock region show distinct haemal arch facets. These are slightly concave and saddle-shaped in outline with low ridge-like margins. Medially, the haemal arch facets border the very weakly concave, spool-shaped depression for the haemal canal.

Remarks

All of the ichthyosaur vertebral centra examined can be distinguished from those of basal ichthyopterygians by their disc-like shape and strong anteroposterior compression (the more plesiomorphic Grippidia having cylindrical centra, Montani 1999). The absence of any further diagnostic features restricts attribution of the specimens to Ichthyosauria gen. et sp. indet. However, tentative assignment of the remains to *cf. Platypterygius longmani* is justifiable on the basis of: 1) overall similarity to *P. longmani* vertebral material described from the Allaru Mudstone and Toolebuc Formation, Queensland (Wade 1990) and Darwin Formation (Murray 1985, 1987 *sensu* Wade 1990); and 2) current recognition of *P. longmani* as the only valid ichthyosaur species from the Aptian–Albian of Australia (Wade 1990; Bardet et al. 1994; Arkhangelsky 1998; Montani 1999).

Buchholtz (2001) discussed differentiation of structural units within the vertebral column of Jurassic ichthyosaurs with relation to variation in swimming styles between taxa. Following on from this study, it can be suggested that differences observed in the Darwin Formation centra (relating to regionalised morphological variation along the vertebral column) can be used to predict preferred swimming style in the Cretaceous *P. longmani*. The marked increase in height proportionate to width, and anteroposterior compression of the tail stock relative to trunk centra, in the Darwin Formation specimens is comparable to the condition recorded in derived thunniform-model

ichthyosaurs such as *Ophthalmosaurus icenicus* and *Stenopterygius quadrissicus* (Buchholtz 2001). Wade (1990) and Broili (1907) noted that the anterior fluke centra in *P. longmani* and *P. platydactylus* were distinctly higher than wide, a feature also conforming to the predicted thunniform condition. Taken together therefore, these characteristics may suggest that *Platypterygius* spp. employed an axial oscillatory swimming mode and probably shared many other key traits (see Montani 1999; Buchholtz 2001) with derived thunniform-model ichthyosaurs.

SAUROPTERYGIA Owen, 1860

PLESIOSAURIA de Blainville, 1835

PLESIOSAUROIDEA (Gray, 1825) Welles, 1943

Plesiosauroidea gen. et sp. indet.

Material

SAM P35431 (Figs 3A, B, C), incomplete and badly weathered element tentatively identified as the ventral plate portion of a left ischium. Orientation is based on position of the lateral margin and its attitude relative to the horizontal axis; SAM P35434 (Figs 4A, B, C), right ischium lacking part of anteromedial margin.

Locality

Casuarina Beach, north of Darwin, Northern Territory. Darwin Formation, Aptian or Albian.

Description

Dimensions of remains are: SAM P35431, total length of 96.7 mm; total width is 98.9 mm; maximum height is lateral extremity is 22.5 mm; maximum length of lateral extremity is 55.3 mm; maximum height of ventral plate is 45.9 mm. SAM P35434, total length is 74.6 mm; total width

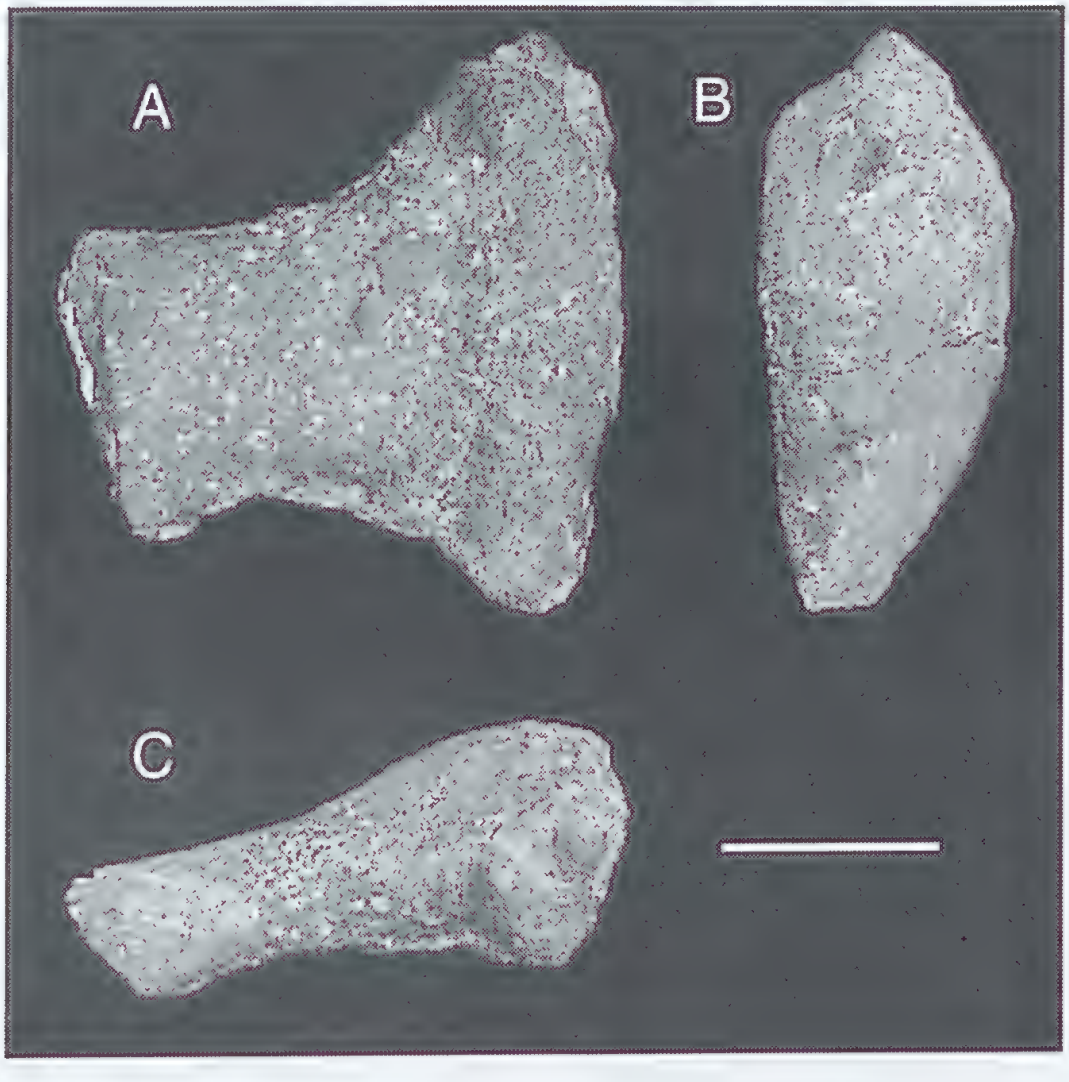

FIGURE 3. SAM P35431, Plesiosauroidea gen. et sp. indet. partial ischium in (A) dorsal, (B) medial and (C) posterior views. Scale bar is 40 mm.

FIGURE 4. SAM P35434, Plesiosauroidea gen. et sp. indet. ischium in (A) dorsal, (B) posterior and (C) lateral views. Scale bar is 40 mm.

is 97.4 mm; maximum height of the of lateral articular surface is 52.1 mm; maximum length of lateral articular surface is 46.1 mm; maximum height of ventral plate is 10.8 mm. Both SAM P35431 and SAM P35434 are hatchet-shaped in dorsal outline with an anteroposteriorly expanded ventral plate. The lateral articular extremity of SAM P35434 is massive but has been lost in SAM P35431. Medially, the ventral plate portion of both elements is dorsoventrally compressed with an inclined medial edge for contact with the opposing ischium. This surface is oriented approximately 10° ventral to a horizontal plane through the lateral articular extremity, and is deeply pitted, suggesting the presence of cartilage. Both the dorsal and ventral surfaces of the ventral plate in SAM P35434 are rugose, possibly for attachment of the m. puboischiofemoralis internus and m. p. externus, respectively. A weak ridge on the posteromedial margin of the ventral plate may also have supported slips of the m. ischiotrochantericus. The ventral plate of both specimens is not greatly anteroposteriorly expanded (with total length being just slightly less than the total transverse width of each element) and is separated from the lateral articular extremity by a constricted waist-like midsection. This is ovoid to circular in cross-section, becoming increasingly dorsoventrally thickened towards the lateral articular surface (not preserved in SAM P35431). The articular surface itself is convex, with the rectangular anterior pubis facet

offset approximately 195° relative to the longitudinal axis of the articular surface. The pubis facet is separated posteriorly from the rectangular median acetabular facet, and in turn from the lobate posterior-most ilial facet (offset approximately 150° relative to the longitudinal axis of the articular surface) by weak parallel ridges. The articular surface margin is produced into a crennate rim, which is continuous ventrally, with a low rugose tuberosity possibly marking part of the m. puboischiofemoralis internus attachment.

Remarks

Despite being heavily weathered, SAM P35431 is identified as the ventral plate portion of a plesiosaurian left ischium on the basis of its hatchet-shaped outline and general morphology. Nevertheless, the specimen is unusual in its markedly dorsoventrally deep, medial articular margin. SAM P35431 was initially registered as an ichthyosaurian humerus belonging to *Platypterygius* sp. However, such an identification is unlikely as the humeri of *Platypterygius* spp. are much more robust, with rectangular to spool-shaped dorsal outline and prominent ridge-like tuberosities on both the dorsal and ventral surfaces (eg Kiprijanoff 1881; Broili 1907; Kuhn 1946; McGowan 1972; Wade 1984; Murray 1987; Choo 1999). SAM P35431 also differs from the larger girdle elements of *Platypterygius* spp., in which the coracoid is subcircular in outline with dorsoventrally deep glenoid/intercoracoid facets (Broili 1907; Wade 1984), and both the scapula and ischiopubis are strap-like with predominantly narrow, ridge-like articular surfaces (Broili 1907; Nace 1939; Murray 1987).

SAM P35434 probably represents a juvenile individual because of its small size and poor ossification of the articular surfaces. Both it and SAM P35431 can be assigned to Plesiosauroidea on the basis of their anteroposteriorly short ventral plates. This differs from the condition in pliosauroids in which the ventral plate of the ischium bears a marked posterior expansion (Mehl 1912; Andrews 1913; Tarlo 1959, 1960; Brown 1981). The presence of a relatively weak posterior expansion in *Eurycleidus* (Cruickshank 1994) and *Leptocleidus* (pers. obs, AM F99374 from the Aptian–Albian Bulldog Shale of Coober Pedy, South Australia), however, suggests that this character state may not be universal for the group. SAM P35434 is unusual in its proportionately massive articular head relative to the ventral plate. The phylogenetic significance of this feature, if any, is uncertain because of its immature stage of development.

ELASMOSAURIDAE Cope, 1869

Elasmosauridae gen. et sp. indet.

Material

SAM P35432 (Figs 5A, B, C, D), a single weathered posterior cervical vertebral centrum.

Locality

Casuarina Beach, north of Darwin, Northern Territory. Darwin Formation, Aptian or Albian.

Description

The surface of the centrum is badly weathered with very little periosteal bone remaining. Total length is 72.8 mm; width of anterior surface is 109.5 mm; depth of anterior surface is 85.2 mm. In general proportions, the centrum is anteroposteriorly short relative to both the height and width of the anterior articular surface. Both the lateral and ventral surfaces are shallowly concave, with the ventral surface being pierced by two large foramina. The articular surfaces are poorly preserved but clearly platycoelous, with a raised convex rim. The neural arch facets are indistinct but prominent bosses high on the lateral surface of the centrum indicate positioning of the rib facets.

Remarks

SAM P35432 is tentatively assigned to Elasmosauridae on the basis of its platycoelous articular surfaces. Murray (1987) reported an elasmosaurid cervical with very shallowly concave articular facets from the Casuarina Beach locality. Brown (1981, 1993) and Bardet et al. (1999) regarded the presence of platycoelous articular surfaces on the cervical centra to be a potential synapomorphy for Elasmosauridae. The character state has also been recorded in the Maastrichtian cryptoclidid *Morturneria* (Chattergee & Small 1989), though Bardet et al. (1991) suggested that this taxon may represent a derived elasmosaurid.

The proportionately short centrum length relative to height of SAM P35432 differs from the common condition in elasmosaurids (such as that described by Murray 1987), in which the cervical centra are markedly elongate (Brown 1993; Bardet et al. 1999). The presence of relatively short cervical centra is considered plesiomorphic among

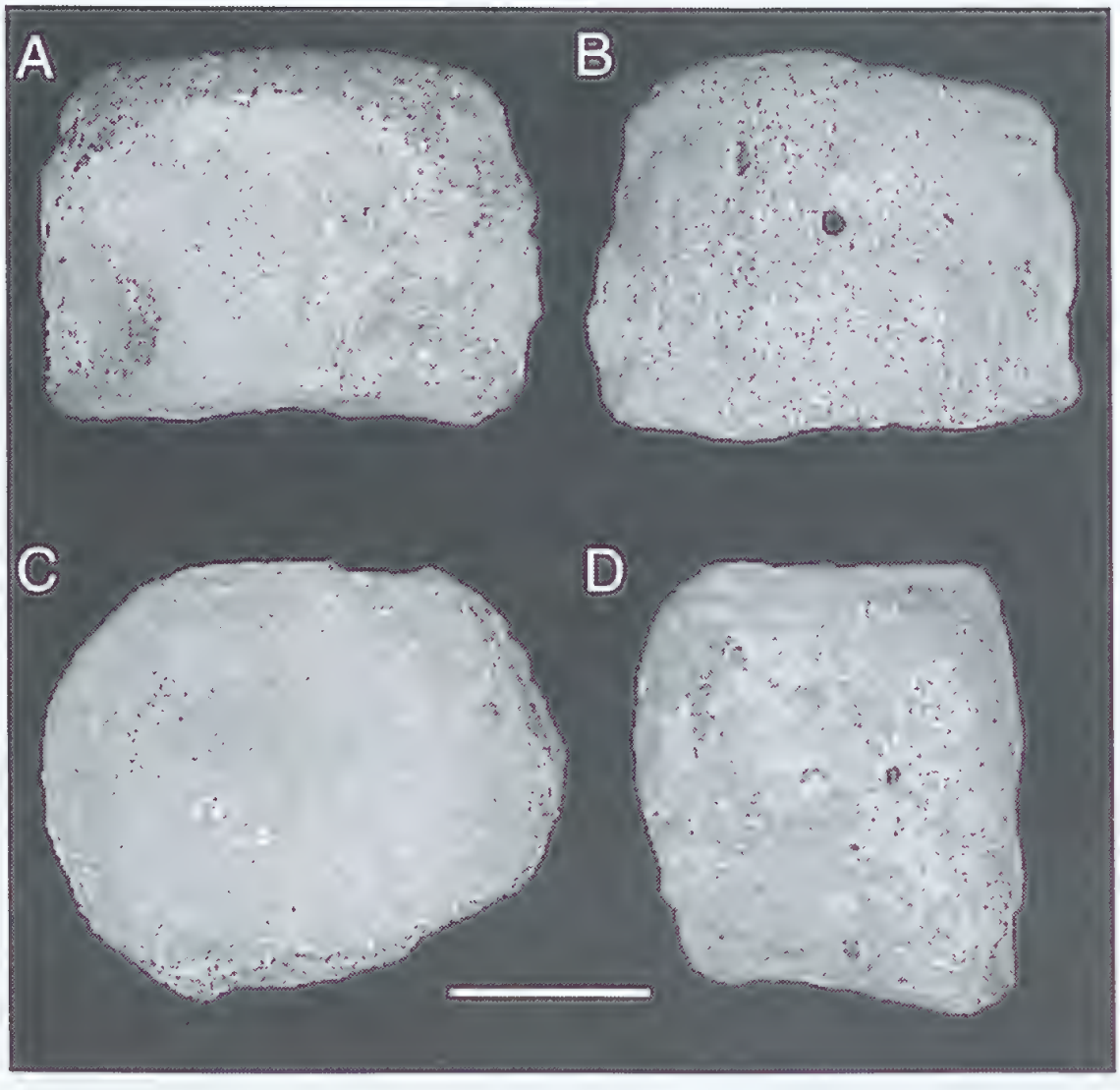

FIGURE 5. SAM P35432, Elasmosauridae gen. et sp. indet. posterior cervical centrum in (A) dorsal, (B) ventral, (C) anterior and (D) lateral views. Scale bar is 40 mm.

plesiosauroids (Brown 1993; Bardet *et al.* 1999). However, the feature has been described in the potential elasmosaurid taxa (*sensu* Bardet et al. 1991) *Aristonectes* (Cabrera 1941) and *Morturneria* (Chattergee & Small 1989) as well as in indeterminate elasmosaurid posterior cervicals from unspecified (probably Albian) deposits near Oodnadatta (Freytag 1964) and the Neales River region (SAM P6181, Persson 1960), South Australia; Toolebuc Formation, Queensland (Kear 2001); and Molecap Greensand, Western Australia (Long & Cruickshank 1998). The presence of proportionately elongate cervicals may therefore not necessarily be universal amongst elasmosaurids, with some taxa exhibiting relatively short centra, particularly in the posterior cervical region.

SAM P35432 is notable for its possession of a raised convex rim surrounding the central concavity of the articular surface. Brown et al. (1986) and Brown (1993) considered this a plesiomorphic condition commonly associated with members of the Cryptoclididae and Plesiosauridae. In contrast, elasmosaurids, including basal taxa such as *Occitanosaurus* (Bardet et al. 1999) and *Muraenosaurus* (Andrews 1910; Brown 1981, 1993), generally exhibit a more open V-shape, in which the articular surface margins form an abrupt angle with the centrum sides. A similar trait is evident in elasmosaurid material from the Toolebuc Formation of Queensland (Kear 2001), and is indicated (but not described) in the figured Darwin Formation specimen (NTM P8727-70; Fig. 1, p. 97) of Murray (1987). Carpenter (1996), however, considered articular rim morphology to be a variable character amongst plesiosaurs and of questionable diagnostic value.

PLIOSAUROIDEA Seeley, 1874

PLIOSAURIDAE Seeley, 1874

Leptocleidus Andrews, 1922

Leptocleidus sp.

Material

SAM P35053, cast of NTM P913-5 (Figs 6A, B, C) right femur.

Locality

Casuarina Beach, north of Darwin, Northern Territory. Darwin Formation, Aptian or Albian.

Description

A near complete right femur lacking part of posterodistal margin. Total length is 260.8 mm; total proximal length is 47.9 mm; total proximal height (including trochanter) is 51.5 mm; width across base of dorsal trochanter is 37.2 mm; total distal length (not including missing posterior margin) is 91.6 mm; total distal height is 25.9 mm. The anterior edge of the femur is weakly sigmoidal, with a strongly convex distal extremity. The posterior edge is uniformly concave along its entire length. Both the dorsal and ventral surfaces are shallowly concave along their longitudinal axis; however, the ventral surface becomes convex and upturned towards the distal extremity. Proximally, the femur is greatly dorsoventrally expanded and separated from its distal section by a constricted neck. The dorsal trochanter is robust and anteroposteriorly constricted at its base. It is separated from the ovoid glenoid articular surface by a shallow groove. The surfaces of both the dorsal trochanter and glenoid articulation are deeply pitted, suggesting the presence of cartilage.

The femoral shaft is weakly anteroposteriorly constricted and ovoid in cross-section, with its posterior margin bearing a raised rugose tuberosity, possibly for attachment of the m. caudifemoralis. A second low tuberosity is present on the median ventral surface and may represent part of the m. puboischiofemoralis insertion. The distal femoral extremity is fan-shaped in dorsoventral outline, with a weakly projecting anterodistal margin. The distal articular surface is narrow and elliptical, with a raised median ridge separating the very large radial facet from the remains of the ulnar facet.

FIGURE 6. SAM P35053 (cast of NTM P913-5), *Leptocleidus* sp. femur in (A) anterior, (B) dorsal and (C) proximal views. Scale bar is 40 mm.

Remarks

Despite the poor existing knowledge of femoral morphology in *Leptocleidus* spp., SAM P35053 (NTM P913-5) can be readily distinguished from the proportionately shorter and stouter propodials of elasmosaurids (Brown 1981; Murray 1987) by its anteroposteriorly broad, flat femoral shaft, greatly expanded distal extremity and sigmoidal anterior margin. These characteristics are very similar to those of the fragmentary femora of *L. capensis* (Andrews 1911) and well-preserved material (AM F99374, SAM P15980) from the Bulldog Shale of South Australia (Figs 7A, B). The femur of *L. clemai* (Cruickshank & Long 1997) differs in its possession of a concave anterior margin. This feature, along with a proportionately more slender shaft, is also present in the femora of polycotylids and most other pliosauroids (Andrews 1913; Welles 1943, 1962; Brown 1981; Storrs 1999). A sigmoidal anterior femoral and humeral margin has, however, been

TABLE 2. Marine reptile groups from Early Cretaceous deltaic-marine deposits of Australia. Pliosauroids are separated into small-bodied (eg *Leptocleidus*) and large-bodied (eg *Kronosaurus*) forms because of their differing ecological roles. The poorly known taxon *'Cimoliasaurus maccoyi'* is recorded separately because of its unknown affinity. Indeterminate plesiosaur material from the marine Bungil Formation, Queensland and freshwater deposits of the Griman Creek Formation, New South Wales, and Strzeleki and Otway Groups, Victoria is excluded pending a more thorough examination of the remains. Taxa from the opal bearing deposits of White Cliffs, New South Wales are placed within the Wallumbilla Formation in accordance with the lithostratigraphic nomenclature of Burton & Mason (1998). Source texts include: Etheridge (1904)[1], Longman (1924)[2], Tierchert & Matheson (1944)[3], Persson (1960[4], 1963[5], 1982[6]), Ludbrook (1966)[7], Condon (1968)[8], Pledge (1980)[9], Smart & Senior (1980)[10], Gaffney (1981)[11], Molnar (1982[12], 1991[13]), Wade (1984[14], 1990[15]), Murray (1985[16], 1987[17]), Hocking et al. (1987)[18], Burger (1988)[19], Bardet (1992)[20], Thulborn & Turner (1993)[21], Krieg & Rodgers (1995)[22], Cruickshank & Long (1997)[23], Henderson (1998)[24], Long (1998)[25], Long & Cruickshank (1998)[26], Cruickshank et al. (1999)[27], Choo (1999)[28], Kear (2001)[29].

Darwin Formation (Money Shoals Platform) Aptian/Albian	Wallumbilla Formation (Eromanga Basin) Aptian–Albian	Allaru Mudstone (Eromanga Basin) Albian	Toolebuc Formation (Eromanga Basin) Albian
Ichthyosauria[3,13,15,16,17] Elasmosauridae[13,17] Small pliosaurid[27]	Ichthyosauria[13] Elasmosauridae[4,5,12,13,25] Large pliosaurid [1,2,4,5,12,13,21,25] Polycotylidae[4,5,13] *'C. maccoyi'*[1,4,13]	Ichthyosauria[12,13,14,15,25] Elasmosauridae[4,5,12,13,25] Chelonioidea[13,25]	Ichthyosauria[12,13,14,15,25] Elasmosauridae[4,5,6,12,13,21,25,29] Large pliosaurid[2,4,5,12,13] Polycotylidae[21,25,27] Chelonioidea[11,12,13,25]
Shallow near-shore marine[24] / paralic[10] / possibly tidal[16]	Coastal / offshore shallow marine[10,19]	Shallow marine[10]	Shallow marine[10]

cited as a potentially diagnostic character state for the polycotylid genus *Polycotylus* (Storrs 1999).

Discussion

The Darwin Formation sediments have been interpreted as representing a shallow near-shore marine/paralic (Smart & Senior 1980; Henderson 1998) to possibly tidal (Murray 1985) depositional environment. The presence of the small pliosaurid taxon *Leptocleidus*, known elsewhere from freshwater and near-shore marine deposits (Andrews 1911, 1922; Strömer 1935; Cruickshank 1997; Cruickshank & Long 1997; Cruickshank et al. 1999), is consistent with this interpretation.

A comparison (Table 2) of the Darwin Formation marine reptile fauna with those known from Early Cretaceous deltaic-marine deposits elsewhere in Australia (Wallumbilla Formation [Doncaster Member], Allaru Mudstone, Toolebuc Formation and Mackunda Formation, Queensland; Bulldog Shale, South Australia; Wallumbilla Formation [Doncaster Member], New South Wales; Birdrong Sandstone and Barrow Group, Western Australia) indicates greatest compositional similarity to the Hauterivian–Barremian Birdrong Sandstone fauna, with ichthyosaurs, elasmosaurids and the small-bodied pliosaurid *Leptocleidus* represented. Throughout the Early Cretaceous marine deposits, ichthyosaurs show a wide distribution (occurring in all currently recognised deposits except the Albian Mackunda Formation and unspecified Berriasian subsurface sediments of the Barrow Group), as do elasmosaurids, which have been recorded from all localities except those of the Albian Mackunda Formation and Berriasian Barrow Group.

Cruickshank et al. (1999) indicated the possible presence of cryptoclidids in the Aptian–Albian Bulldog Shale. This is supported by more recent observations of the South Australian fauna (Kear unpubl.) but as yet the group has not been recorded from any other Australian deposit.

The distribution of small- and large-bodied pliosaurid taxa in the Australian Early Cretaceous is variable, with smaller forms (represented by at least two species of *Leptocleidus*, Cruickshank et al. 1999) confined to the Darwin Formation,

TABLE 2. (cont.)

Mackunda Formation (Eromanga Basin) Albian	Bulldog Shale (Eromanga Basin) Aptian–Albian	Birdrong Sandstone (Carnarvon Basin) Hauterivian–Barremian	Barrow Group (Carnarvon Basin) Berriasian
Polycotylidae[13]	Ichthyosauria[9,13,20] Elasmosauridae[9,27] Small pliosaurid[9,25,27] Large pliosaurid[9] Cryptoclididae?[27]	Ichthyosauria[3,13,28] Elasmosauridae[26,27] Small pliosaurid[23,27]	Small pliosaurid[26]
Paralic[10]	Shallow marine[22] / offshore[7]	Coastal near-shore shallow marine[18] / paralic[8]	Fluviatile-deltaic[18]

Bulldog Shale and Birdrong Sandstone. Larger pliosaurid remains occur only in the Aptian–Albian Wallumbilla Formation (Doncaster Member), Albian Toolebuc Formation and Bulldog Shale deposits. This division may be linked to the different habitat preferences and ecological roles of small- and large-bodied pliosaurid taxa, with offshore environments preferentially supporting larger-bodied forms. An exception is seen in the shallow offshore marine (Ludbrook 1966; Krieg & Rogers 1995) Bulldog Shale, which includes both small- and large-bodied pliosaurid remains (the latter being represented by an isolated tooth, SAM P22525, from the opal-bearing sediments of Coober Pedy, figured by Pledge 1980, p. 8).

Distribution of polycotylids in the shallow marine (Smart & Senior 1980; Burger 1988) Wallumbilla Formation, Toolebuc Formation and paralic (Smart & Senior 1980) Mackunda Formation may, as with large-bodied pliosaurids, be related to a preference for predominantly offshore marine environments. However, individuals also appear to have readily frequented more inshore habitats, as suggested by their occurrence in the Mackunda Formation deposits.

Restriction of chelonioids to the upper Albian Allaru Mudstone and Toolebuc Formation may be the product of both the group's temporal distribution (the earliest-known chelonioid being recorded from the upper Aptian – lower Albian Santana Formation of Brazil, Hirayama 1997, 1998) as well as environmental factors such as prevailing water temperatures. Studies of sedimentary sequences (Frakes & Francis 1988; Frakes & Krassay 1992; Frakes et al. 1995; Constantine et al. 1998), climatic modelling (Barron & Washington 1982) and isotope data (Gregory et al. 1989; Pirrie et al. 1995) have suggested that strongly seasonal climates with winter freezing and at least seasonal sea ice characterised high latitudes in the Early Cretaceous of Australia. Such conditions may well have been unfavourable to chelonioids and provided an effective barrier to the group's dispersal into the Australian region prior to the upper Albian.

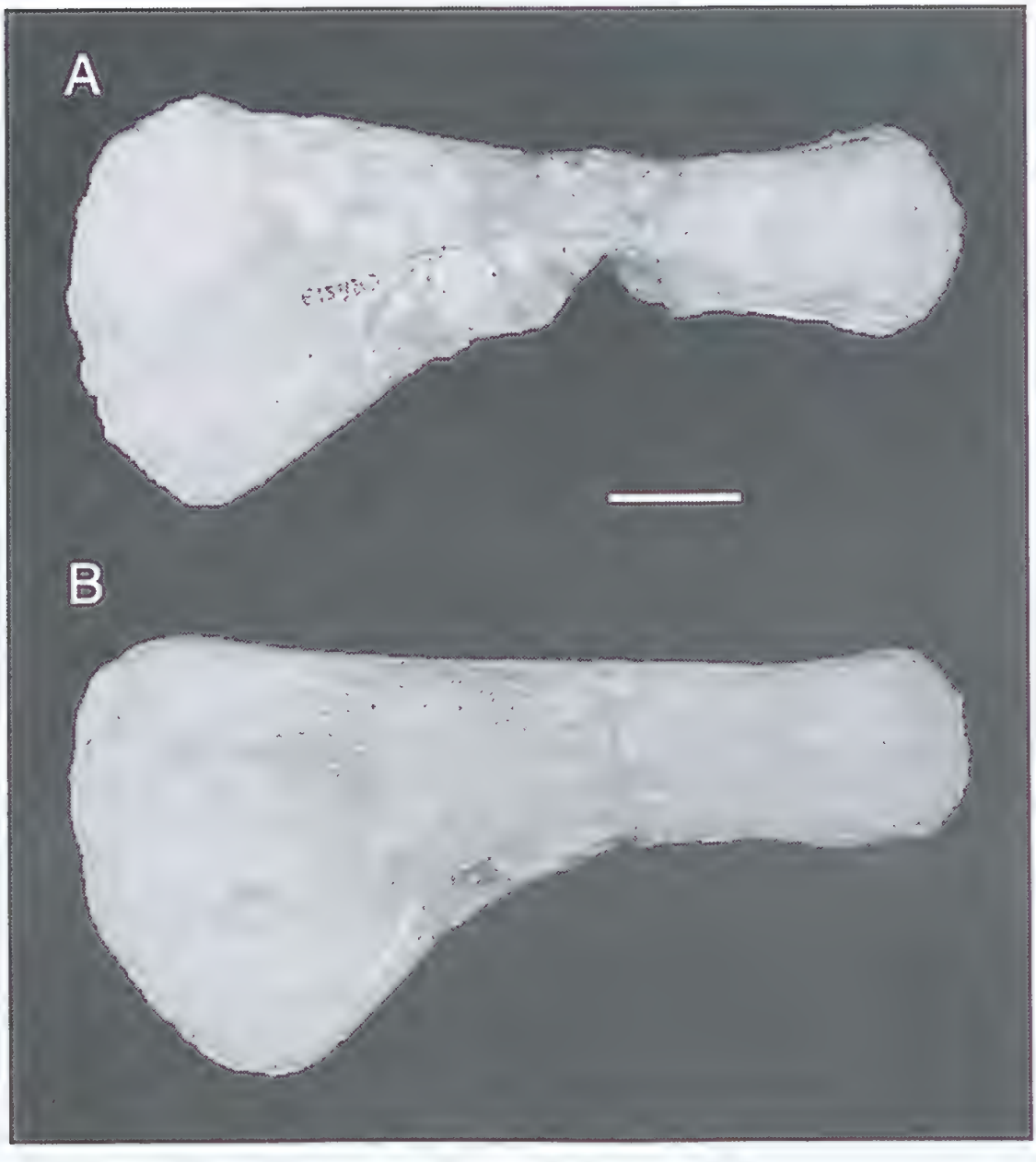

FIGURE 7. SAM P15980 juvenile *Leptocleidus* sp. humerus (A) and femur (B) from Andamooka, South Australia. Scale bar is 20 mm.

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TENTACULARIID CESTODES OF THE ORDER TRYPANORHYNCHA (PLATYHELMINTHES) FROM THE AUSTRALIAN REGION

H. W. PALM & I. BEVERIDGE

PALM, H. W. & BEVERIDGE, I. 2002. Tentacullariid cestodes of the order Trypanorhyncha (Platyhelminthes) from the Australian region. *Records of the South Australian Museum* 35(1): 49–78.

The present study summarises information on tentacullariid trypanorhynchs from Australian waters. A total of 19 species from the genera *Nybelinia* Poche, 1926, *Heteronybelinia* Palm, 1999, *Mixonybelinia* Palm, 1999, *Kotorella* Euzet & Radujkovic, 1989 and *Kotorelliella* gen. nov. were identified: *N. aequidentata* (Shipley & Hornell, 1906); *Nybelinia africana* Dollfus, 1960; *N. hemipristis* sp. nov.; *N. jayapaulazariahi* Reimer, 1980; *N. mehlhorni* sp. nov.; *N. schmidti* Palm, 1999; *N. scoliodoni* (Vijayalakshmi, Vijayalakshmi & Gangadharam, 1996); *N. strongyla* Dollfus, 1960; *N. thyrsites* Korotaeva, 1971; *N. victoriae* sp. nov.; *Heteronybelinia australis* sp. nov.; *H. estigmena* (Dollfus, 1960); *H. pseudorobusta* sp. nov.; *Mixonybelinia beveridgei* (Palm, Walter, Schwerdtfeger & Reimer, 1997); *M. cribbi* sp. nov.; *M. edwinlintoni* (Dollfus, 1960); *M. southwelli* Palm & Walter, 1999; *Kotorella pronosoma* (Stossich, 1901) and *Kotorelliella jonesi* gen. et sp. nov. The new genus *Kotorelliella* is characterised by a homeoacanthous, heteromorphous metabasal armature and a basal armature with additional interpolated hooks on the external surface of the tentacle, thus appearing heteroacanthous. The new species appears to be closely related to *Kotorella pronosoma*. The tentacullariid trypanorhynch fauna in Australian waters is species rich, with 22 (48%) of the total of 46 known species occurring in waters of the region. Eleven new locality, and 20 new host records are reported.

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Palm (1999), Palm et al. (1997), Palm and Overstreet (2000) and Palm and Walter (1999, 2000) partially revised the trypanorhynch cestode family Tentacullariidae Poche, 1926 on the basis of material deposited in museums in London, Paris, Vienna and the United States. Following the erection of two new genera, *Heteronybelinia* Palm, 1999 and *Mixonybelinia* Palm, 1999 by Palm (1999), Palm and Walter (2000) gave a summary of the current state of knowledge within the tentacullariid trypanorhynch genera. Thus, to date, a total of 39 species of *Kotorella*, *Nybelinia*, *Heteronybelinia* and *Mixonybelinia* are considered valid (Palm & Walter 2000).

There is little known about the tentacullariid trypanorhynchs from Australian coastal waters. The first collections were made by a French scientific expedition under the command of Nicolas Baudin between 1801 and 1803 (Beveridge & Campbell 1996), but the cestodes, *Tentacularia coryphaenae* Bosc, 1797 and an unidentified species of *Nybelinia* were not described until 1942 (Dollfus 1942). Korotaeva (1971) named the *Nybelinia* species of Dollfus (1942) *N. thyrsites* and subsequently (Korotaeva 1974) reported additional unidentified *Nybelinia* spp. from other fishes from southern Australia. Lester et al. (1988) and Sewell and Lester (1988) reported *Tentacularia* sp. from orange roughy, *Hoplostethus atlanticus* Collett, 1889 off the coasts of South Australia and Tasmania; while Sewell and Lester (1995) found *Nybelinia* sp. in jewfish, *Rexea solandri* (Cuvier & Valenciennes, 1832) from southern Australian waters. Beveridge and Campbell (1996) recorded *Tentacularia coryphaenae* Bosc, 1797, *Nybelinia thyrsites* Korotaeva, 1971 and *N. sphyrnae* Yamaguti, 1952 from Australian fishes; while Jones and Beveridge (1998) added *N. queenslandensis* from a carcharhinid shark as a new species. Palm (1999) recorded *Nybelinia lingualis* (Cuvier, 1817) from southern Australian waters and Speare (1999)

reported Nybelinia sp. from sailfish, *Istiophorus platypterus* (Shaw & Nodder, 1792) off the coast of Queensland. Thus, a total of five tentacullariid species has been described from Australia.

Last and Stevens (1994) summarised knowledge of the Australian chondrichthyan fauna, the definitive hosts of trypanorhynchan cestodes, as being extremely rich and consisting of 296 species, 54% of them endemic. In terms of host-specificity and zoogeography of trypanorhynch cestodes, the Australian fauna might therefore harbour a high number of endemic and locally distributed tentacullariid trypanorhynchs, such as was observed within the related family Eutetrarhynchidae by Beveridge (1990). Palm (1999) and Palm and Walter (2000) suggested that many tentacullariids, for example *Tentacularia coryphaenae* and *Nybelinia lingualis*, exhibit a cosmopolitan or circumtropical distribution pattern. However, records from the south-west Pacific and south-east Indian Ocean are scarce. For example, the tentacullariids *Tentacularia coryphaenae*, *Nybelinia africana* and *N. scoliodoni* were only recently recorded from Indonesian coastal waters (Palm 2000). Other records which might confirm a wide distribution and possibly a low degree of host specificity for these trypanorhynchs are still lacking.

The present study was carried out to examine the species of *Nybelinia*, *Heteronybelina*, *Mixonybelinia* and *Kotorella* deposited in museum collections in Australia as well as in the collection of the junior author. Where necessary, the specimens are described and illustrated as emendations to currently available descriptions. Apart from the establishment of new host and locality records, species identifications provide further insight into the zoogeographical distribution of tentacullariid cestodes. The comparison of the specimens with earlier descriptions allows comments to be made on the extent of intraspecific morphological variability within tentacullariid trypanorhynchs. Together with the study of deposited tentacullariids from other collections (Palm 1999; Palm & Overstreet 2000; Palm and Walter 1999, 2000), the present study summarises the current state of knowledge on the genera of tentacullariid cestodes.

Material And Methods

Specimens were examined from the Australian Helminthological Collection (AHC) housed in the South Australian Museum (SAM), Adelaide, as well as the Queensland Museum (QM), Brisbane. Special attention was given to unidentified specimens deposited simply as *Nybelinia* sp. Unmounted specimens were stained in Celestine Blue, dehydrated in ethanol, cleared in methyl salicylate and mounted in Canada balsam. Pieces of strobilae were embedded in paraffin, serial sections were cut at a thickness of 5 µm and stained with haematoxylin and eosin. Drawings were made using an Olympus BH2 microscope with an ocular micrometer and drawing tube. Terminology for morphological features peculiar to the Trypanorhyncha follows Dollfus (1942) and Campbell and Beveridge (1994).

The following measurements were made: scolex length (SL), scolex width at level of pars bothridialis (SW), pars bothridialis (pbo), pars vaginalis (pv), pars bulbosa (pb), pars postbulbosa (ppb), velum (vel), appendix (app), bulb length (BL), bulb width (BW), bulb ratio (BR), scolex proportions of pbo:pv:pb (SP), tentacle width (TW) and tentacle sheath width (TSW). If possible, the tentacle length (TL) was estimated. The tentacular armature was described as follows: armature homeomorphous or heteromorphous, number of hooks per half spiral row (hsr), total hook length (L) and the total length of the base of the hooks (B). The abbreviation 'nm' (not measured) indicates that no measurement was taken. All measurements are given in micrometers unless otherwise indicated. Specimens belonging to the same species from different hosts or localities were measured in the same order as cited in the material examined. If more than three measurements were taken from a single host species, the mean is given with the range in parentheses. Because tentacullariid cestodes are morphologically uniform and the genera are well defined, the species descriptions presented here are restricted to key differential features. Illustrations are provided if useful for future species identification; otherwise the reader is referred to illustrations given by other authors. The classification utilised follows Palm (1995, 1997). Host identity follows Last and Stevens (1994) for the elasmobranchs and FishBase 1998 (Froese & Pauly 1998) for the teleosts.

Systematics

A total of 19 species were identified, and 11 new locality and 20 new host records were established. Seven new species are described and

a new tentacullariid genus is erected: *Nybelinia hemipristis* sp. nov., *N. mehlhorni* sp. nov., *N. victoriae* sp. nov., *Heteronybelinia australis* sp. nov., *H. pseudorobusta* sp. nov., *Mixonybelinia cribbi* sp. nov. and *Kotorelliella jonesi* gen. et sp. nov. Detailed information on individual specimens with comments on their taxonomy and distribution are provided below.

Order TRYPANORHYNCHA Diesing, 1863

Superfamily TENTACULARIOIDEA Poche, 1926

Family TENTACULARIIDAE Poche, 1926

Genus *Nybelinia* Poche, 1926

Nybelinia aequidentata Shipley & Hornell, 1906 (Figs 1–2)

Material examined

From *Dendrochirus zebra* (Cuvier, 1829): 1 postlarva, Noumea, New Caledonia, Nov. 1997, coll. S. Pichelin (QM G 218031).

Description

SL = 7900 (Fig. 1); SW = 1775; pbo = 2975; pv = 4950; pb = 1575; vel = 925; app = 1400; BL = 1417 (1400–1450); BW = 280 (270–290); BR = 5.1:1; SP = 1.9:3.1:1. Basal tentacular swelling absent. TW basal = 100–110, TW metabasal = 110–120. Tentacle sheaths straight, TSW = 80–100, prebulbar organs and muscular rings around basal part of tentacle sheaths not visible. Retractor muscles originate in basal parts of bulbs. Tentacular armature homeoacanthous, homeomorphous (Fig. 2); distinctive basal armature absent. Hooks falciform, with slender shaft, stout base and strongly recurved tip, L = 57.5–65.0; B = 17.7–22.5. Hooks decrease in size towards apical region and towards base L = 35.0–57.5; B = 12.5–17.5. Smallest hook measured L = 17.5; hsr = 7–8.

Remarks

The present specimen has one of the largest scoleces among *Nybelinia* species. In addition, the postlarva is characterised by falciform hooks over 60 in length and a bulb ratio greater than 4. The postlarva is most similar to *Nybelinia aequidentata* Shipley & Hornell, 1906, described by Shipley and Hornell (1906), Pintner (1927) and Palm (1999). Shipley and Hornell (1906) recorded the type specimen as having a scolex 4–5 mm long. The hook shape of the present specimen corresponds with those of the type, though the hooks in the present specimen are larger (57–65 compared with 49 in the type according to Shipley and Hornell (1906) or 33–38 reported by Palm (1999). Pintner (1927) redescribed the type and added information on the bulb ratio (4.3:1), hook length (48) and scolex measurements (SW = 1900, pbo = 1500, pb = 1600 and vel = 600). He also remarked that the hooks were not uniform in size but increased from the base towards the metabasal region and then decreased in the apical region of the armature. Thus, although the scolex and hook sizes of the present specimen are distinctly larger than those described from the type specimen, it has been identified as *N. aequidentata*. The present finding represents a new host and locality record.

Nybelinia syngenes Pintner, 1929 is the only other species of *Nybelinia* which has been described as having tentacular hooks with a length greater than 60 and with a similar hook form and armature pattern. However, the scolex of this species, described originally from *Sphyrna zygaena* (Linnaeus, 1758), is distinctly smaller. Whether *N. aequidentata* exhibits variation in scolex size, as described for *N. lingualis* (Cuvier, 1817) and *Heteronybelinia yamaguti* (Dollfus, 1960) (see Dollfus 1942; Palm et al. 1997; Palm 1999; Palm & Walter 2000) is not known. Palm (1999) has suggested that this might be the case for a postlarva from *Lepturacanthus savala* (Cuvier, 1829) with a scolex length of 3400, a bulb ratio of 3.3:1 and slender falciform hooks 33–38 in length.

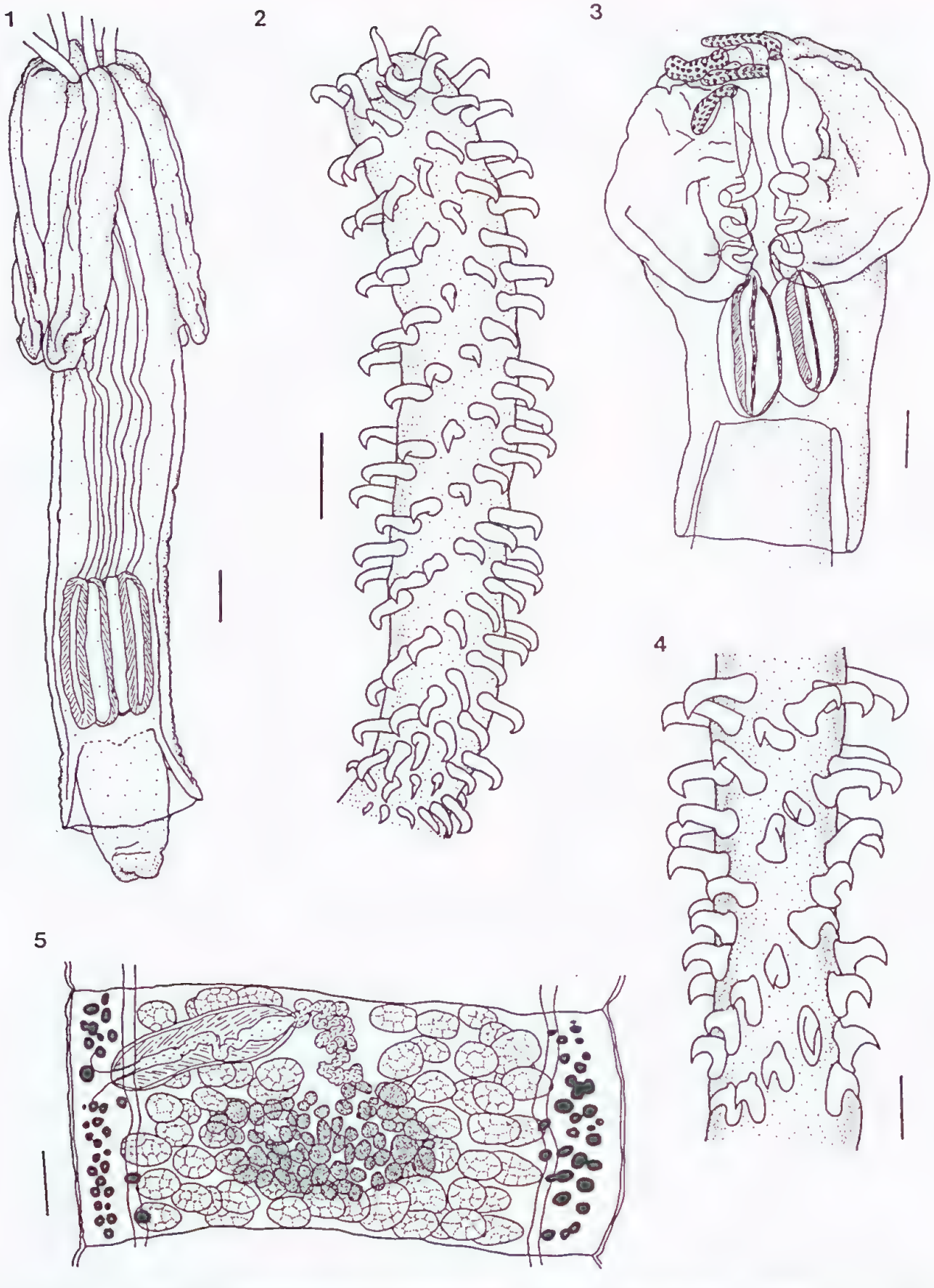
Nybelinia africana Dollfus, 1960 (Figs 3–5)

Material examined

From unidentified shark: 1 adult, Queensland, coll. J. C. Pearson (QM G 218169).

Description

SL = 1780 (Fig. 3); SW = 1134; pbo = 930; pv = 840; pb = 523; vel = 417; BL = 439 (423–459); BW = 163 (157–171); BR = 2.7:1; SP = 1.8:1.6:1. TW metabasal = 47–50. Basal tentacular swelling absent. Tentacle sheaths spirally coiled; TSW = 65–70. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths not seen. Retractor muscles



FIGURES 1–2. *Nybelinia aequidentata* Shipley & Hornell, 1906 from *Dendrochirus zebrae*. QM G 218031. **1.** Scolex. **2.** Homeomorphous armature with falciform hooks. Scale bars: Figure 1, 500 µm; Figure 2, 100 µm. FIGURES 3–5. *Nybelinia africana* Dollfus, 1960 from an unidentified shark. QM G 218169. **3.** Scolex. **4.** Basal and metabasal armature. **5.** Mature proglottid. Scale bars: Figure 3, 200 µm; Figure 4, 20 µm; Figure 5, 100 µm.

originate in basal parts of bulbs. Tentacular armature consists of homeomorphous hooks along tentacle (Fig. 4). Tentacles not completely evaginated; metabasal armature differs distinctly from basal armature. Basal 2–3 rows of rosethorn-shaped hooks with distinct anterior extension of base, L = 14–16, 16–17; metabasal hooks larger, falciform with small base, strongly recurved at tip, L = 26–27; B = 10–13. Strobila 57 mm long, with about 215 acraspedote segments which enlarge in size towards end of strobila, maximum width 1.48 mm; velum straight or very slightly scalloped; first segments 15–30 x 600–675, mature segments (Fig. 5) wider than long, 220–470 x 650–970 (n = 4). Pre-gravid segments (with some eggs) 440–670 x 1150–1480 (n = 5); terminal pre-gravid segment with rounded end. In mature segments, genital pore ventro-submarginal, in anterior half or anterior third of segment; genital pore to anterior end 90–150 in mature and 180–200 in pre-gravid segments; genital pores alternate irregularly. Cirrus sac thin-walled, elongate, 370–480 x 70–100 (n = 5), length:width ratio 4.5:1 (3.7–5.0:1), distal pole directed anteromedially, nearly reaching anterior end of proglottid, cirrus unarmed; internal and external seminal vesicle absent. Vas deferens greatly coiled, extends to midline of segment, then posteriorly towards female genital complex. Testes of varying shape, 60–90 in diameter, arranged in single layer centrally and in double layer peripherally; testis number 50–71 per segment, between 5 and 8 testes anterior to cirrus (n = 5). Ovary follicular, in centre of segment, bilobed, each lobe 190–260 x 140–220, increasing in size along strobila. Vitelline follicles encircle medulla, follicles 30–50 in diameter. Ventral and dorsal osmoregulatory canals 30 in diameter, testes extend external to ventral canal but not beyond dorsal canal.

Remarks

The present specimen closely resembles *N. africana* Dollfus, 1960 as described by Dollfus (1960) and Palm (1999) in having rosethorn-shaped basal hooks, changing to falciform metabasal hooks of similar size and shape. Additionally, the segment morphology with number and size of segments, size of cirrus sac, testes and vitelline follicles, as well as arrangement of the genital complex is similar. However, some differences were observed between the present specimen and *N. africana*. The specimen from Australia differs in having 2 to 3 rows of basal hooks with a distinct anterior extension of the base (Fig. 4), which has not been reported in other specimens of *N. africana*. However, Dollfus (1960, figs 14, 17) illustrated comparable basal hooks, some with an anterior extension of the base. The scolex is larger in the Australian specimen (1780) compared with other material (1118–1568) (Palm et al. 1997) and the testis number is smaller. However, as most other morphological characters correspond, the specimen is identified as *N. africana* and the observed differences are considered to be due to intraspecific morphological variability. The present finding is a new locality record for the species.

Nybelinia hemipristis sp. nov.
(Figs 6–9)

Types

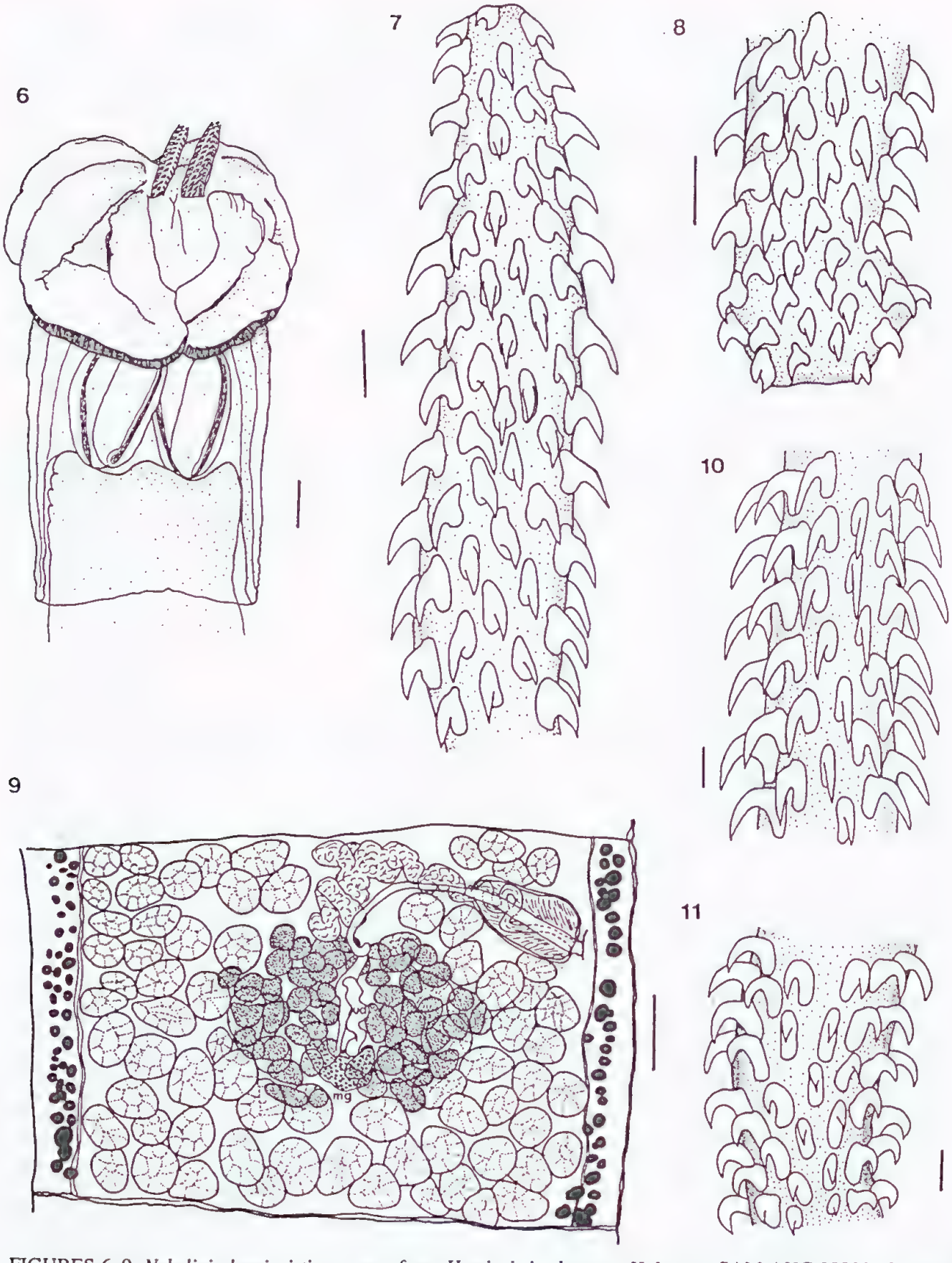
Holotype from stomach of *Hemipristis elongata* Klunzinger, 1871, Balgal, Queensland, coll. B. G. Robertson, 16.ix.1985 (SAM AHC 28309). Paratypes: 3 specimens, *Hemipristis elongatus*, Marchinbar Island, Northern Territory, coll. G. Cuthbertson, 25.v.1985 (SAM AHC 28310).

Material examined

Types.

Description

SL = 2030 (Fig. 6); SW = 1230; pbo = 1000; pv = 860; pb = 560; vel = 630; BL = 553 (550–560); BW = 218 (210–220); BR = 2.5:1; SP = 1.8:1.5:1. Tentacles short, massive, decreasing in diameter towards apical region; basal tentacular swelling absent. TW basal and metabasal = 75–85, TW apical = 37.5–62.5. Tentacle sheaths straight (TSW = 50–60), prebulbar organs and muscular rings around basal part of tentacle sheaths not seen. Retractor muscles originate in basal parts of bulbs. Tentacular armature homeoacanthous, homeomorphous (Fig. 7); distinctive basal armature absent (Fig. 8). Hooks slender, rosethorn-shaped with anterior elongation of base, increasing in size from basal (L = 15.5–30.0; B = 16.3–20.0) towards metabasal regions (L = 35.0–40.0; B = 25.0–27.5), then decreasing in size towards apical (L = 27.5–32.5; B = 15.0–20.0) region; hsr = 6. Strobila acraspedote, velum straight; 33 mm long, maximum width 1030, number of segments 300. Mature segments (Fig. 9) wider than long, 600–670 x 750–920. Genital pore submarginal, 200 from anterior end, alternating irregularly. Cirrus sac short and stout, 180–210 x 50–100 (n = 5), length:width ratio 2.9:1 (2.0–3.6:1), distal pole directed



FIGURES 6–9. *Nybelinia hemipristis* sp. nov. from *Hemipristis elongata*. Holotype, SAM AHC 28309. **6.** Scolex. **7.** Metabasal armature. **8.** Basal armature. **9.** Mature proglottid. Note short cirrus sac, the uterine duct (ud), and the Mehlis' gland (mg). Scale bars: Figure 6, 200 µm; Figures 7–8, 40 µm; Figure 9, 100 µm. FIGURES 10–11. *Nybelinia jayapaulazariahi* Reimer, 1980 from a 'sole'. QM G 207318. **10.** Metabasal armature. **11.** Basal armature. Scale bars: Figures 10–11, 10 µm.

anteromedially, not reaching anterior end of segments, cirrus unarmed; internal and external seminal vesicle absent. Vas deferens coiled, extends to midline of segment, then posteriorly towards female genital complex. Testes 84–97 in number, 55–85 in diameter centrally and 40–60 peripherally, distributed in single layer; arranged in 2 lateral groups, confluent posterior to ovary; extend between ovarian lobes, about 6–7 testes anterior to cirrus sac. Ovary in centre of segment, ovarian lobes 200–260 x 120–160. Vagina ventral to cirrus sac. Vitelline follicles encircle medulla; follicles 25–40 in diameter.

Remarks

The present specimens, with rosethorn-shaped hooks diminishing in size towards the apical armature and a strobila consisting of acraspedote segments, resemble *N. anthicosum* Heinz & Dailey, 1974. However, the species differ in having different scolex forms, tentacles, tentacular armatures and sizes. *N. anthicosum* has an elongated prominent velum, long tentacles and tentacular hooks which are distinctly spaced (see Heinz & Dailey 1974). The largest hooks occur in the 7th to 9th rows. *N. hemipristis* sp. nov. has a massive scolex with a shorter velum (Fig. 6), short tentacles and tentacular hooks which are tightly spaced along the tentacle. The largest hooks are in the 10th to 14th rows. In the last few hook rows, the size and number of hooks per half spiral row decrease rapidly (Fig. 7). In *N. anthicosum* the hook size diminishes gradually towards the apical part of the tentacle. As with *N. anthicosum*, *N. hemipristis* is a species without a characteristic basal armature and with a smaller basal than metabasal hook size, therefore belonging to species subgroup 'Aa' of Palm (1999).

The description of the strobilar characters of *N. hemipristis* demonstrates that this species has a very characteristic, short, stout cirrus sac, with a length:width ratio of 2 in some segments, a feature unusual in most species of *Nybelinia*. However, this character might prove to be of taxonomic significance in the future.

The new species is named after the elasmobranch host genus, *Hemipristis*.

Nybelinia jayapaulazariahi Reimer, 1980
(Figs. 10–11)

Material examined

From 'sole', either *Synaptura nigra* Macleay, 1880 or *Aseraggodes macleayanus* (Ramsay, 1881): 1 postlarva, Moreton Bay, Queensland, coll. J. C. Pearson, 1968 (QM G 207318).

Description

SL = 1060; SW = 700; pbo = 470; pv = 450; pb = 365; BL = 323 (320–325); BW = 119 (85–135); BR = 2.7:1; SP = 1.3:1.2:1. TW = 32.5–35; hsr = 6. Basal tentacular swelling absent. Retractor muscles originate in basal parts of bulbs. Tentacular armature consists of homeomorphous slender uncinate hooks, L = 15.0–16.3, B = 11.2–13.7 (Fig. 10). Size of hooks diminishes towards basal part of tentacle, L = 11.2–13.7, B = 8.7–11.2 (Fig. 11).

Remarks

N. jayapaulazariahi was originally described from *Cynoglossus* sp. from the Bay of Bengal, India by Reimer (1980). Palm (1999) redescribed the species from another host, *Harpodon nehereus* (Hamilton-Buchanan, 1822), also from India. The tentacular armature has characteristic, slender, regularly curved hooks which increase in size towards the metabasal part of the tentacle. The present specimen, also from a 'sole', has a similar hook shape (compare Fig. 4 with Fig. 5 of Palm 1999) and bulb ratio, while it differs in having a larger scolex (1060 in the present specimen compared with 530 described previously) and hook size (11.2–16.3 in the current specimen compared with 5.6–11.2 in previous descriptions). However, the present specimen was in a poor state of preservation, and the larger scolex might be related to the slightly larger hook size. A small scolex of about 0.5–1.0 mm, together with the uncinate hook form, is characteristic for *N. jayapaulazariahi*, and soles seem to be important intermediate hosts. The present finding represents a new locality record for the species.

Nybelinia mehlhorni sp. nov.
(Figs 12–14)

Types

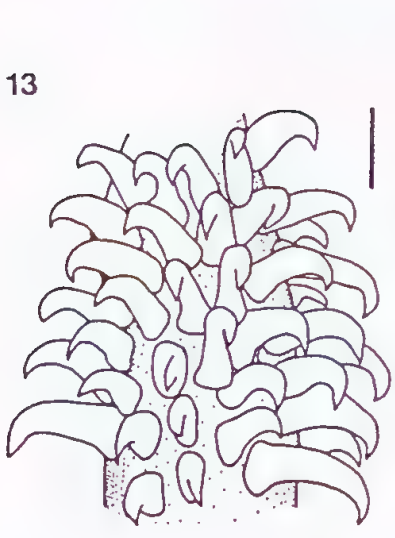
Holotype from stomach of *Hemigaleus microstoma* Bleeker, 1852, Heron Island, Queensland, coll. P. McBoarman, 20.xii.1995 (QM G 218032); paratype, same data (QM G 218033).

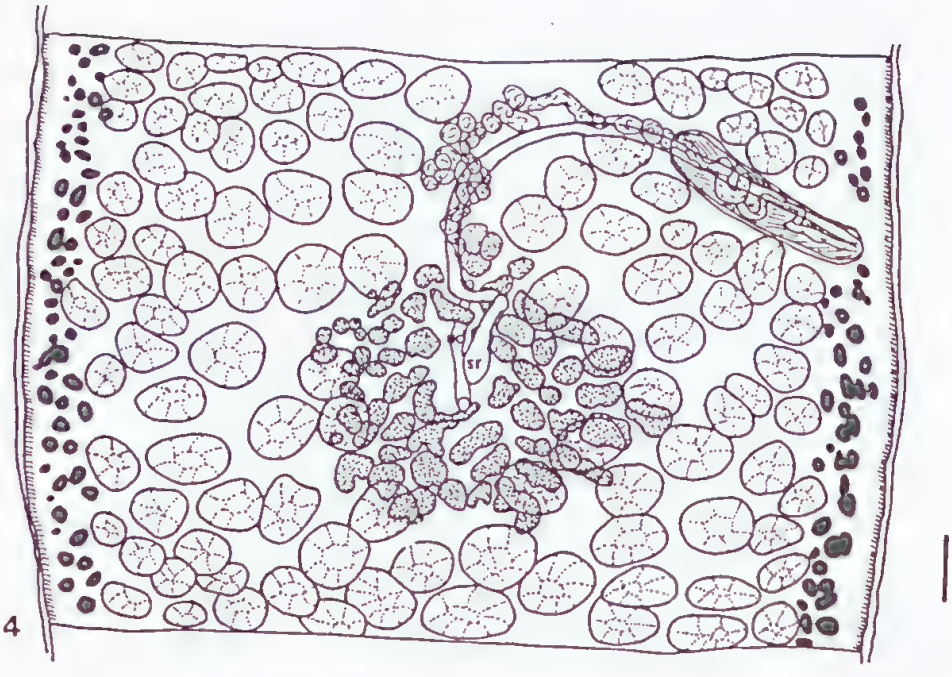
Material examined

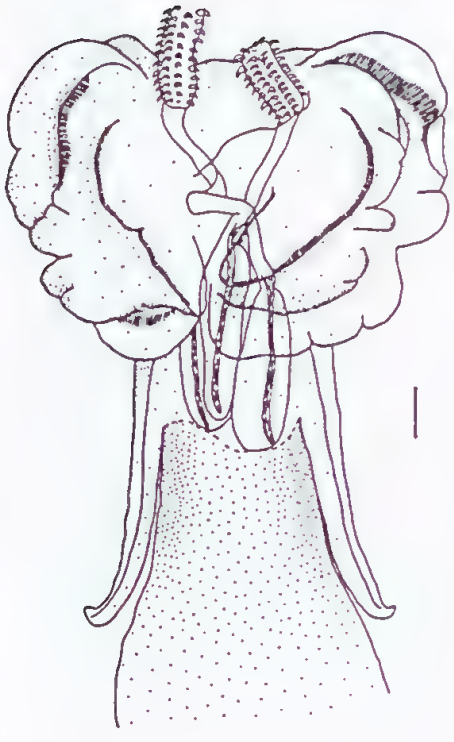
Types.

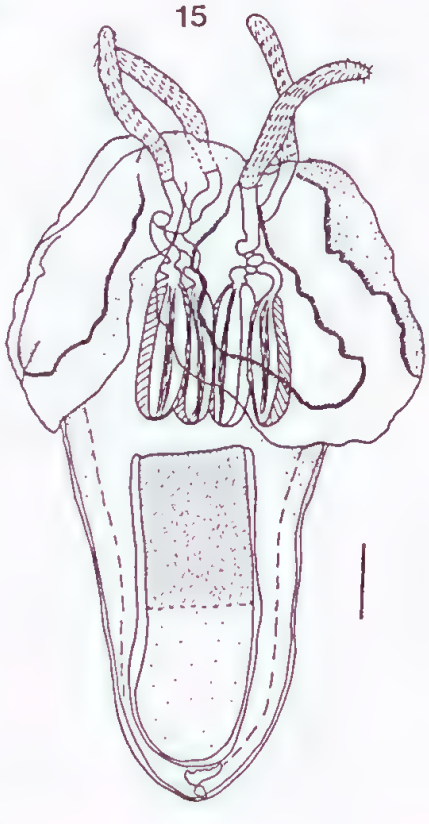
Description

SL = 560 (Fig. 12); SW = 400; pbo = 330;









FIGURES 12–14. *Nybelinia mehlhorni* sp. nov. from *Hemigaleus microstoma*. Types, QM G 218032–3. **12.** Scolex. **13.** Metabasal and apical armature. **14.** Mature proglottid. Note the uterine duct (ud) and the seminal receptacle (sr). Scale bars: Figure 12, 50 µm; Figure 13, 10 µm; Figure 14, 50 µm. FIGURES 15–16. *Nybelinia scoliodoni* (Vijayalakshmi, Vijayalakshmi & Gangadharam, 1996) from *Diodon hystrix*. QM G 218035–7. **15.** Scolex. **16.** Basal and metabasal armature, external surface. Scale bars: Figure 15, 150 µm; Figure 16, 25 µm.

pv = 125; pb = 250; vel = 200; BL = 178 (150–200); BW = 58 (50–70); BR = 3.1:1; SP = 1.3:0.5:1. Tentacles short; basal tentacular swelling absent; TW = 22.5–27.5. Tentacle sheaths sinuous to spirally coiled (TSW = 17.5–20.0); muscular rings around basal part of tentacle sheaths seen. Retractor muscles originate in basal parts of bulbs. Tentacular armature homeoacanthous, homeomorphous (Fig. 13); distinctive basal armature absent. Hooks falciform, with stout base, elongated handle and strongly recurved tip. Hooks increase in size from basal (L = 3.5–7.5, B = 2.5–5.0) to metabasal region (L = 15.0–17.5, B = 6.3–8.7) then decrease towards apex (L = 11.3–13.8, B = 2.5–4.3); hsr = 7. Small worms, length 25 (16) mm, maximum width 950 (700) with 135 (90) segments. Strobila acraspedote, velum straight; pre-mature (testes visible) proglottids (Fig. 14) 80–280 long x 560–790 wide; mature segments (female genitalia developed) wider than long, 380–600 x 600–900; terminal segment 830 x 800. Genital pore almost lateral, 130–200 from anterior end (190 in terminal segment); pores alternate irregularly. Cirrus sac elongate, 170–220 x 40–60 (n = 5) in mature segments, length:width ratio 4.1:1 (2.8–5.5:1), distal pole directed anteromedially, not reaching anterior end of segments; cirrus unarmed, internal and external seminal vesicles absent. Vas deferens greatly coiled in midline of segments, extending posteriorly towards female genital complex. Testes 103–120 in number, 80 x 95 in size, smaller testes peripheral, 35–40 in size, distributed in single layer; testes in 2 lateral groups confluent posterior to ovary; 10–16 testes anterior to cirrus sac. Vagina tubiform, 30 in diameter, ventral to cirrus sac, passes anteromedially to midline, then posteriorly to ovary; seminal receptacle present, 60–90 x 25–50. Ovary in centre of segment, ovarian lobes 250–300 x 160–210. Vitelline follicles encircle medulla, follicles 30–45 in diameter. Uterine pore absent.

Remarks

Following Palm (1999), *N. mehlhorni* sp. nov. belongs to *Nybelinia* species without a characteristic basal armature and a basal hook size smaller than the metabasal one, thus belonging to the subgroup 'Aa'.

On the basis of the hook shape, the species resembles *N. aequidentata* (Shipley & Hornell, 1906) and *N. goreensis* Dollfus, 1960. While the former is much larger than the present specimen, the latter species has different scolex proportions as well as a different hook arrangement, as illustrated recently by Palm and Walter (2000).

N. mehlhorni sp. nov. also resembles *N. bengalensis* Reimer, 1980 in its falciform hooks and in hook size (Reimer 1980). However, *N. bengalensis* can be distinguished by having a distinctly different scolex form and size, a bulb ratio of about 2, long and slender tentacle sheaths and tentacles with spaced falciform hooks (Reimer 1980). By contrast, *N. mehlhorni* sp. nov. has short tentacles with hooks tightly spaced along the tentacle. The scolex (0.56 mm in total length) is much smaller.

The new species is named in honour of Prof. Heinz Mehlhorn, Heinrich-Heine-University, Düsseldorf.

Nybelinia schmidti Palm, 1999

Material examined

From *Isurus oxyrhinchus* Rafinesque, 1810: 1 adult, Bicheno, Tasmania, coll. B. G. Robertson, 24.iv.1987 (SAM AHC 28313).

Description

SL = 1600; SW = 850; pbo = 1040; pv = 680; pb = 340; vel = 600; BL = 298 (270–330); BW = 131 (110–150); BR = 2.3:1; SP = 3.0:2.0:1. TW basal = 45–48, TW metabasal = 30.0–32.5; hsr = 5–6. Basal tentacular swelling absent. Tentacle sheaths spirally coiled, TSW = 25–40. Prebulbar organs absent, muscular rings present around the tentacle sheaths. Retractor muscles originate in basal part of bulbs. Tentacular armature homeoacanthous, homeomorphous, consisting of massive rosethorn-shaped hooks with anterior extension of base, size in metabasal region L = 13.8–15.0, B = 11.3–12.5, decreasing towards base, L = 8.8–11.3, B = 6.2–8.8. Characteristic basal armature absent. Strobila immature with few segments, acraspedote; segments wider than long (660–690 x 15–60).

Remarks

The present specimen closely resembles that of the type, also from *Isurus oxyrhinchus* (syn. *Isurus glaucus*), in having similar scolex proportions and almost identical hook sizes. Other species with a similar tentacular armature are *Nybelinia strongyla* Dollfus, 1960 and *Heteronybelinia australis* sp. nov. (*vide infra*). While the latter species differs in having homeomorphous hooks of different sizes on the

internal and external tentacle surfaces as well as smaller basal hooks, *N. strongyla* differs in scolex proportions and larger hook sizes. The present record extends the range of distribution from the South African to the southern Australian coast.

Nybelinia scoliodoni (Vijayalakshmi, Vijayalakshmi & Gangadharam, 1996) (Figs 15–16)

Material examined

From *Diodon hystrix* Linnaeus, 1758: Heron Island, Queensland, 2 postlarvae, coll. J. Sakanari, 23.viii.1986 (QM G 218034); 8 postlarvae, coll. M. K. Jones, 6.vii.1995 (QM G 218035–218037); 8 postlarvae, coll. T. H. Cribb, Jan. 1997 (QM G 218038–218041).

From *Makaira indica* (Cuvier, 1832): 1 postlarva, Cape Bowling Green, Queensland, coll. P. Speare, 18.ix.1987 (SAM AHC 21351).

From *Istiophorus platypterus* (Shaw & Nodder, 1792): Whitsunday Island, Queensland, coll. P. Speare, 5.xii.1988 (SAM AHC 21351).

From *Carcharhinus limbatus* (Valenciennes, 1839): 1 adult, stomach, Bremer Island, Northern Territory, coll. J. Stevens, 29.v.1985 (SAM AHC 28314).

Description

SL = 1350, 1115 (Fig. 15); SW = 860, 800; pbo = 670, 520; pv = 230, 210; pb = 300, 320; vel = 330, 330; app = 310, 200; BL = 288 (280–300), 282 (260–300); BW = 115 (110–120), 125 (120–130); BR = 2.5:1, 2.3:1; SP = 2.2:0.8:1, 1.6:0.7:1. Tentacles nearly completely evaginated, TL = 390, 375; basal tentacular swelling absent. TW at basal armature 35, 30; TW at metabasal armature 50, 45; TW at apex 30, 25. Tentacle sheaths sinuous, TSW = 30, 40; prebulbar organs and muscular rings around basal part of tentacle sheaths not visible. Retractor muscles originate in basal parts of bulbs. Metabasal armature homeoacanthous, homeomorphous; distinctive basal armature present (Fig. 16). Basal armature consists of about 10 rows with compact rosethorn-shaped hooks, increasing in size from L = 4.5, B = 3.9 (row 1) to L = 19.5, B = 11.7 (row 10). From row 11, hook form changes to slender spiniform, L = 22.7, B = 13.0. Metabasal and apical hooks L = 29.9, with small base, B = 11. Number of hooks per half row (hsr) 6–7 in basal region, decreasing to 5 in metabasal and apical regions.

Remarks

Nybelinia scoliodoni is a widely distributed tentacullariid and is here recorded for the first time from Australian waters. The species is easily recognised by its rosethorn-shaped basal armature of about 11 rows which is followed by long, spiniform metabasal hooks. The present specimens correspond with the description given by Palm (1999) in having a similar armature and bulb ratio. They differ in having a larger scolex and hook size. However, they correspond closely to the original description of *Nybelinia* (= *Tentacularia*) *scoliodoni* of Vijayalakshmi et al. (1996). The present findings constitute three new host records. *C. limbatus* has been recorded previously as a definitive host for *N. scoliodoni* by Palm (1999). The specimens described here are the same as those reported by Speare (1999).

Nybelinia strongyla Dollfus, 1960 (Figs 17–20)

Material examined

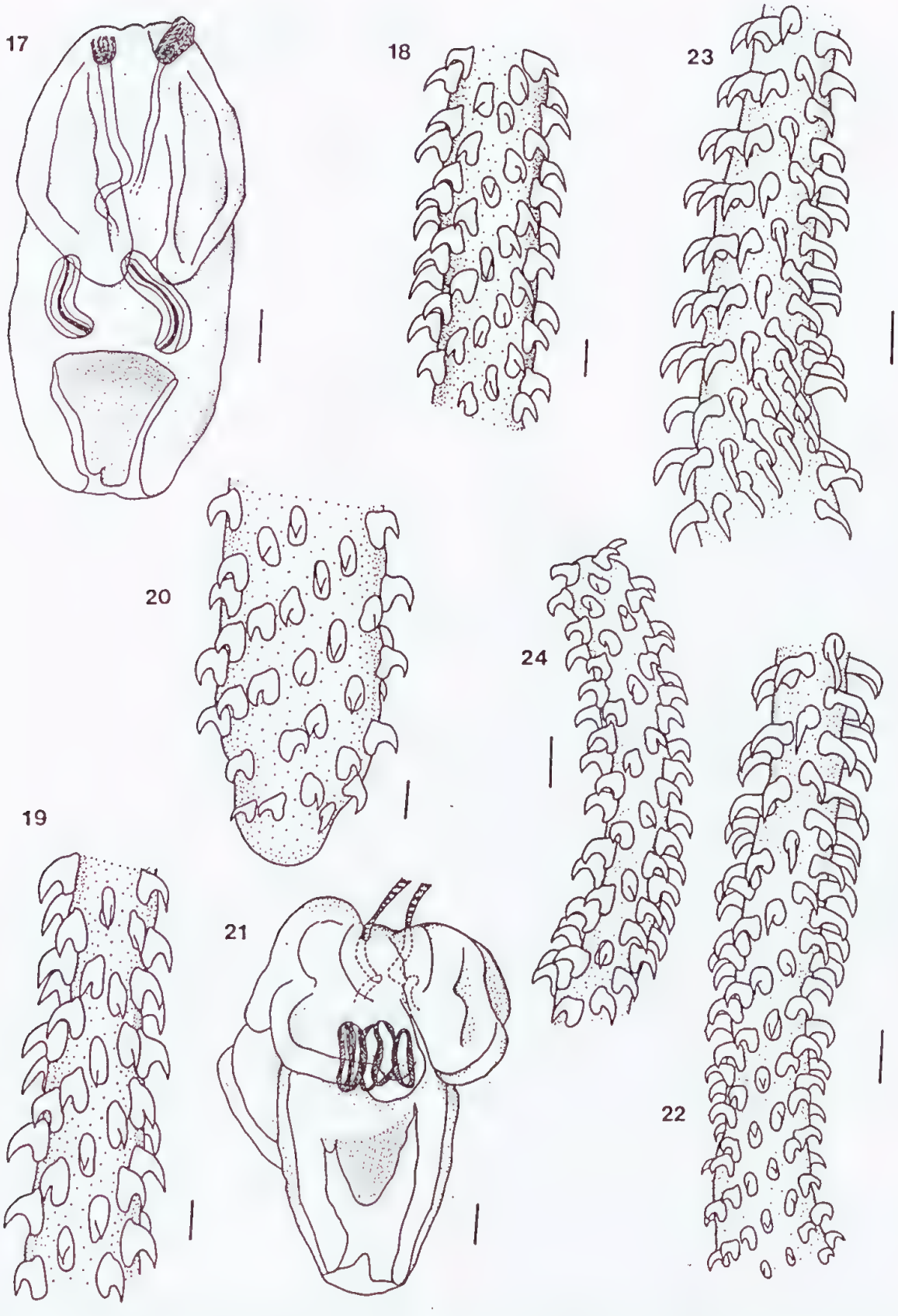
From *Argyrosomus hololepidotus* Lacépède, 1802: 2 postlarvae from stomach, Murray Mouth, South Australia, coll. M. G. O'Callaghan, May 1992 (SAM AHC 28345).

From *Johnius vogleri* (Bleeker, 1853): 1 postlarva from body cavity, Heron Island, Queensland, coll. J. Reddich, Jan 1997 (QM G 218109).

Description

Postlarvae from *A. hololepidotus*: SL = 1303, 1566 (Fig. 17); SW = 648, 796; pbo = 700, 781; pv = 647, 764; pb = 292, 355; vel = 332, 326; app = 374, 429; BL = 286 (244–292), 355 (334–380); BW = 86 (82–90), 98 (92–107); BR = 3.3:1, 3.6:1; SP = 2.4:2.2:1, 2.2:2.2:1. Tentacles not completely evaginated; basal tentacle swelling absent. TW = 50–58, 43–45. Tentacle sheaths sinuous, TSW = 36–40, 36–40; prebulbar organs and muscular rings around basal part of tentacle sheaths not visible. Retractor muscles originate in basal part of bulbs. Tentacle armature homeoacanthous, homeomorphous (Fig. 18); distinctive basal armature absent. Hooks slender, rosethorn-shaped, increasing in size from basal towards metabasal part of tentacle. Metabasal hooks L = 17.5–20.0; B = 13.8–16.3; basal hooks L = 10.0–12.5; B = 10.0–12.5; hsr = 7.

Postlarva from *J. vogleri:* SL = 1880; SW = 1660; pv = 680; pb = 440; BL = 308 (300–325); BW = 129 (115–150); BR = 2.4:1;



FIGURES 17–18. *Nybelinia strongyla* Dollfus, 1960 from *Argyrosomus hololepidotus*. SAM AHC 28345. **17.** Scolex. **18.** Metabasal armature. Scale bars: Figure 17, 150 µm; Figure 18: 15 µm. FIGURES 19–20. *Nybelinia strongyla* from *Johniops vogleri*. QM G218109. **19.** Metabasal armature. **20.** Basal armature. Scale bars: Figure 19–20: 10 µm. FIGURES 21–24. *Nybelinia thyrsites* Korotaeva, 1971 from *Trachurus declivis*. QM G 214194–5. **21.** Scolex. **22.** Basal armature. **23.** Metabasal armature with falciform hooks. **24.** Apical armature with rosethorn-shaped hooks. Scale bars: Figure 21, 200 µm; Figures 22–24, 25 µm.

SP = –:1.5:1. TW basal = 37–40, TW metabasal = 30–33. Basal tentacular swelling absent. Tentacle sheaths straight; TSW = 20–25. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths absent. Retractor muscles originate in basal part of bulbs. Armature homeoacanthous, homeomorphous (Fig. 19); characteristic basal armature absent (Fig 20). Hooks rosethorn-shaped with anterior extension of basal plate; hooks in basal part of tentacle smaller (L = 7.5–10.0; B = 7.5–9.5) than in metabasal (L = 13.8–16.3; B = 10.0–12.5) armature. Number of hooks per half spiral (hsr) diminishes from 6–7 in metabasal region to 5–6 in apical part of tentacle.

Remarks

Nybelinia strongyla Dollfus, 1960 was described from a postlarva from the west coast of Africa, and is characterised by the homeoacanthous tentacular armature with slender rosethorn-shaped hooks, reaching a size of up to 16 in the metabasal armature. Palm and Walter (2000) described adult specimens of *N. strongyla* from Africa. The present specimens correspond closely in their tentacular armature as well as in scolex proportions to those specimens described by Dollfus (1960) and Palm and Walter (2000). Minor variations in the hook pattern are observed within *N. strongyla* but are difficult to define, and many scolex characters within tentacullariids appear to be variable (Palm 1999, Palm and Walter 2000). Therefore, the postlarvae described above are identified as *N. strongyla*. However, some doubt surrounding the identification remains. Further studies are needed to determine whether postlarvae with rosethorn-shaped hooks as described above are conspecific with the African material, or whether they belong to a new species of *Nybelinia*. *Argyrosomus hololepidotus* is a new host record, and the distribution of the species is extended to the southern Australian coast.

The specimen from *J. vogleri*, with rosethorn-shaped hooks, resembles *N. lingualis*, *N. schmidti*, *N. sphyrnae*, *N. strongyla* and *N. thyrsites*. It differs from *N. lingualis* in having basal hooks with an anterior extension of the basal plate, and from *N. thyrsites* in having differently shaped metabasal hooks and a larger bulb ratio (see below). *N. schmidti* differs in having smaller hooks and different scolex proportions. *N. sphyrnae* differs in having slender, more uncinate hooks in the metabasal armature, while the hooks are more massive rosethorn-shaped in *N. strongyla*. In the present specimen, the basal hook length is slightly smaller than described by Palm and Walter (2000) for *N. strongyla*. However, the metabasal hooks are the same size. Although the scolex proportions were difficult to measure in the present specimen, it is also identified as *N. strongyla*, representing a new host and locality record.

Nybelinia thyrsites Korotaeva, 1971
(Figs 21–24)

Material examined

From *Trachurus declivis* Jenyns, 1841: 2 postlarvae from stomach wall, Crayfish Bay, Tasmania, coll. K. B. Sewell, 11.v.1987 (QM G 214194, 212145).

From *Carcharhinus brachyurus* (Günther, 1870): 1 adult from stomach, Goolwa, South Australia, coll. R. Martin, 28.x.1985 (SAM AHC 28312).

From *Mustelus antarcticus* Günther, 1870: 1 adult from stomach, Goolwa, South Australia, coll. R. Martin, 28.x.1985 (SAM AHC 28311).

Description

SL = 2032, 1550 (Fig. 21); SW = 1520, 700; pbo = 1024, 610; pv = 640, 500; pb = 368, 520; vel = 992, 490; app = 496; BL = 358 (355–365), 495 (490–500); BW = 117 (114–120), 155 (140–170); BR = 3.1:1, 3.2:1; SP = 2.8:1.7:1, 1.2:1:1. Tentacle sheaths spirally coiled; TSW = 51–57, 35–45. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths present. Retractor muscles originate in basal part of bulbs. Tentacles long (TL = 832) and slender, basal tentacular swelling absent; TW basal = 38–44, 25–30; TW metabasal = 57.0, 57.7–62.5; TW apical 32.0, 27.5. Characteristic basal armature present (Fig. 22), consisting of about 7–8 rows of homeomorphous, rosethorn-shaped hooks with slight anterior extension, increasing in size towards metabasal armature (1st row hooks: L = 9.5–11.0, B = 8.0–11.0, L = 7.5–8.7, B = 6.3–7.5; 8th row: L = 15.8–17.4, L = 16.2–17.5, B = 11.0–12.6, B = 10.0–12.5). Metabasal armature of about 12–14 rows of hooks, with largest hooks in rows 12–17. Metabasal armature with slender falcate to falciform hooks (L = 21.7–26.9, B = 8.7–11.0; L = 21.3–24.0, B = 11.3–12.5) (Fig. 23). Apical hooks rosethorn-shaped, with hook form changing from slender rosethorn-shaped with slight anterior extension to rosethorn-shaped with distinct anterior extension (Fig. 24).

Hooks diminish in size towards apical region (34th row of hooks: L = 14.2–15.8, B = 11.0–14.2); hsr basal: 6–7; hsr metabasal and apical: 6.

Remarks

N. thyrsites was redescribed in detail by Beveridge and Campbell (1996). The present material corresponds with the redescription given. In addition, the basal hook form differs from the metabasal and apical hooks; thus, the species belongs to subgroup 'Ba' of Palm (1999). The present specimens from *Trachurus declivis* provide a further example in which the postlarvae can be larger than adult worms, and also show variable scolex measurements depending on the state of contraction. *Trachurus declivis* and *Carcharhinus brachyurus* are new hosts for *N. thyrsites*.

Nybelinia victoriae sp. nov.
(Figs 25–26)

Types

Holotype from body cavity of *Lepidotrigla modesta* Waite, 1899, Port Phillip Bay, Victoria, coll. R. Norman, 17.iii.1989 (SAM AHC 28343); paratype, same data (SAM AHC 28344).

Material examined

Types.

Description

SL = 1030, 1050 (Fig 25); SW = 700, 650; Pbo = 570, 450; Pv = 350, 320; Pb = 315, 320; BL = 310 (300–315), 310 (305–320); BW = 124 (115–135), 116 (110–125); BR = 2.5:1, 2.7:1; SP = 1.8:1.1:1, 1.4:1.0:1. Tentacles elongate; basal tentacular swelling absent. TW = 40.0–50.0, 45.0–50.0. Tentacle sheaths sinuous to spirally coiled (TSW = 40.0–50.0, 35.0–40.0); prebulbar organs and muscular rings around basal part of tentacle sheaths not seen. Retractor muscles originate in basal part of bulbs. Armature homeoacanthous, homeomorphous (Fig. 26); distinctive basal armature absent. Hooks falciform, with stout base, elongated handle and strongly recurved tip. Hooks increase in size from basal (L = 7.5–10.0, B = 6.3–8.8) to metabasal region (L = 12.5–15.0, B = 7.0–8.0) and decrease towards apical (L = 11.3–12.5, B = 6.3–8.0) part of tentacle; hsr = 7.

Remarks

This species, with a tentacular armature consisting of slender falciform hooks, increasing in size towards the metabasal region and decreasing in size towards the apical region, resembles *Nybelinia aequidentata* Shipley & Hornell, 1906; *N. syngenes* Pintner, 1927; *N. anantaramanorum* Reimer, 1980; and *N. bengalensis* Reimer, 1980. While the former two species differ in having different scolex proportions and distinctly larger hooks (see remarks on *N. aequidentata*), the present specimens are most similar to *N. bengalensis* and *N. anantaramanorum*. *N. anantaramanorum* has larger hooks and was considered a *species inquirenda* by Palm and Walter (2000). *N. bengalensis* differs in having different scolex proportions, including very short bulbs (BR < 2) (Reimer 1980). Thus, the present specimens represent a new species here named *Nybelinia victoriae* sp. nov., the specific epithet being derived from the Australian state from which samples were collected. With hook size smaller in the basal rather than the metabasal region, the species is considered to belong to subgroup 'Aa' of Palm (1999).

Genus ***Heteronybelinia*** Palm, 1999

Heteronybelinia australis sp. nov.
(Figs 27–30)

Types

Holotype from stomach of *Carcharhinus amboinensis* (Müller & Henle, 1839), St Lawrence, Queensland, coll. B. G. Robertson, 29.x.1985 (SAM AHC 28315); paratype, same data (SAM AHC 28316).

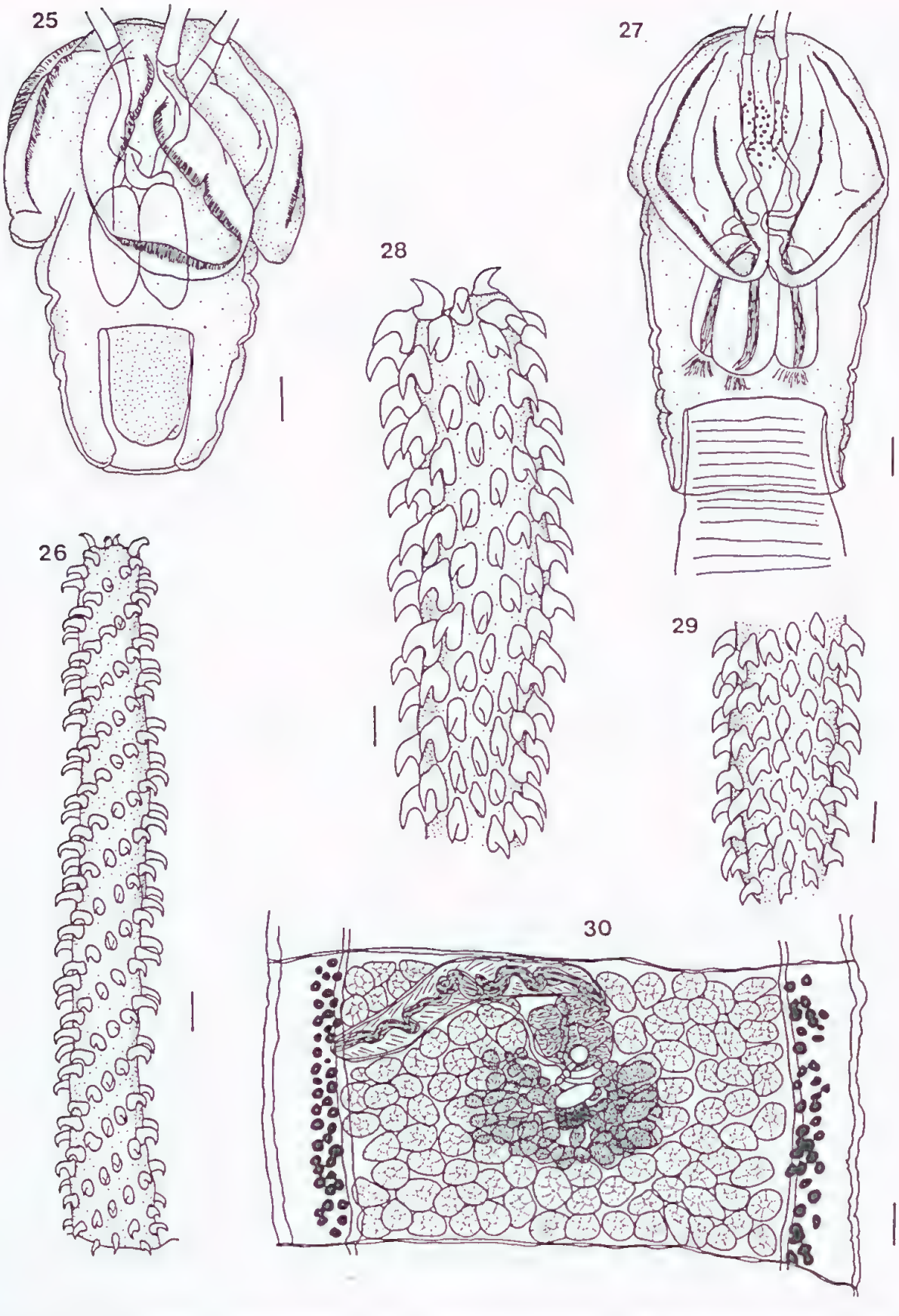
Material examined

From *Carcharhinus amboinensis*: types.

From *Carcharhinus brachyurus*: 1 specimen, Goolwa, South Australia, coll. R. Martin, 28.x.1985 (SAM AHC 28317).

Description

SL = 1190, 1210 (Fig. 27); SW = 660, 680; pbo = 650, 700; pv = 530, 650; pb = 350, 310; vel = 220, 190; BL = 313 (305–320), 308 (290–340); BW = 138 (125–150), 119 (110–130); BR = 2.3:1, 2.6:1; SP = 1.9:1.7:1, 2.3:2.1:1. Tentacle sheaths spirally coiled. TSW = 27.5–32.5, 25.0–35.0. Tentacles robust, TL = 255–290, increasing in width towards apex. TW basal and metabasal 30.0–32.5; basal tentacular swelling absent. Prebulbar organs absent; muscular rings



FIGURES 25–26. *Nybelinia victoriae* sp. nov. from *Lepidotrigla modesta*. Types, SAM AHC 28343–4. **25.** Scolex. **26.** Basal and metabasal armature. Scale bars: Figure 25, 100 µm; Figure 26, 20 µm. FIGURES 27–30. *Heteronybelinia australis* sp. nov. from *Carcharhinus amboinensis*. Types, SAM AHC 28315–6. **27.** Scolex. **28.** Metabasal armature. **29.** Basal armature. **30.** Mature proglottid. Note the uterine pore. Scale bars: Figure 27, 100 µm; Figures 28–29, 10 µm; Figure 30, 50 µm.

around basal parts of tentacle sheaths present. Retractor muscles originate at base of bulbs. Tentacular armature homeoacanthous, heteromorphous, with hooks tightly spaced along tentacle (Fig. 28); characteristic basal armature absent (Fig. 29). Hooks massive, rose-thorn shaped, with slight anterior extension of base, increase in size from basal towards metabasal armature. Hook size differs on bothridial/antibothridial (L = 12.5–15.0, B = 11.3–13.7) and antibothridial/bothridial (L = 11.3–12.5, B = 7.0–8.7) tentacle surfaces (Fig. 28), with two tentacles having largest hooks on bothridial surfaces and two other tentacles having largest hooks on antibothridial surfaces. Basal hooks L = 5.0–7.5, 7.5–8.7; B = 8.7–10.0 (internal) and L = 5.0–6.3, 5.0–7.5; B = 3.8–5.0, 5.0–6.3 (external); hsr = 6–7. Strobila only very slightly craspedote, velum scalloped; total length 18.0 and 15.0 mm, maximum width 640 and 730, with 125 and 155 segments. In holotype, terminal segment pre-mature (320 x 550), segments wider than long, 231 x 630. Genital pores ventro-submarginal, 60 from anterior margin; alternate irregularly. Cirrus sac of pre-mature segments elongate and slender, 210–230 x 35–50 (n = 5), length:width ratio 5.3:1 (4.6–6.0:1), with distal pole directed anteromedially, reaching anterior end of segment (Fig. 30); cirrus unarmed; internal and external seminal vesicles absent. Vas deferens coiled, extends posteriorly from cirrus sac towards female genital complex. Testes 106–130 in number, smallest testes at margin of medulla, distributed in 1–2 layers; in 2 lateral groups, confluent posterior to ovary; extend between ovarian lobes; 8–10 testes anterior to cirrus sac. Ventral osmoregulatory canal 15 in diameter, internal to sinuous dorsal canal, 5 in diameter; 24 prominent bands of longitudinal muscles on each side of strobila. Segments in paratype mature, wider than long (240 x 700 to 380 x 720). Genital pores 110 from anterior margin. Cirrus sac of mature segments (Fig. 30) elongate and slender, 260–320 x 50–60 (n = 5), length:width ratio 5.2:1 (4.3–5.8:1). Central testes 45–65 in diameter, smallest testes peripheral, 30–50 in diameter, distributed in 1–2 layers; ovarian lobes 110–200 x 80–110, seminal receptacle 50–65 x 25–30.

Remarks

Heteronybelinia australis sp. nov. has a unique armature. The tentacular hooks are tightly spaced and appear homeomorphous along the tentacle. However, the hook sizes differ on the bothridial and antibothridial tentacular surfaces. In addition, two tentacles have the largest hooks on the bothridial surfaces while the other two tentacles have the largest hooks on the antibothridial surfaces. Whether this armature pattern is unique or whether it occurs in other tentacullariid species remains to be determined.

The specific epithet indicates the occurrence of the species in Australian waters.

Heteronybelinia estigmena (Dollfus, 1960)
(Figs 31–36)

Material examined

From *Carcharhinus limbatus* Valenciennes, 1839: 16 adults from spiral valve, Geraldton, Western Australia, coll. B. G. Robertson, 27.xi.1986 (SAM AHC 21352, 28318); 4 adults from spiral valve, Nickol Bay, Western Australia, coll. B. G. Robertson, 11.xi.1986 (SAM AHC 28319); 3 adults from spiral valve, Darwin Harbour, Northern Territory, coll. B. G. Robertson, 28.viii.1986 (SAM AHC 28320); 6 adults from spiral valve, Fog Bay, Northern Territory, coll. B. G. Robertson, 4.x.1986 (SAM AHC 28329).

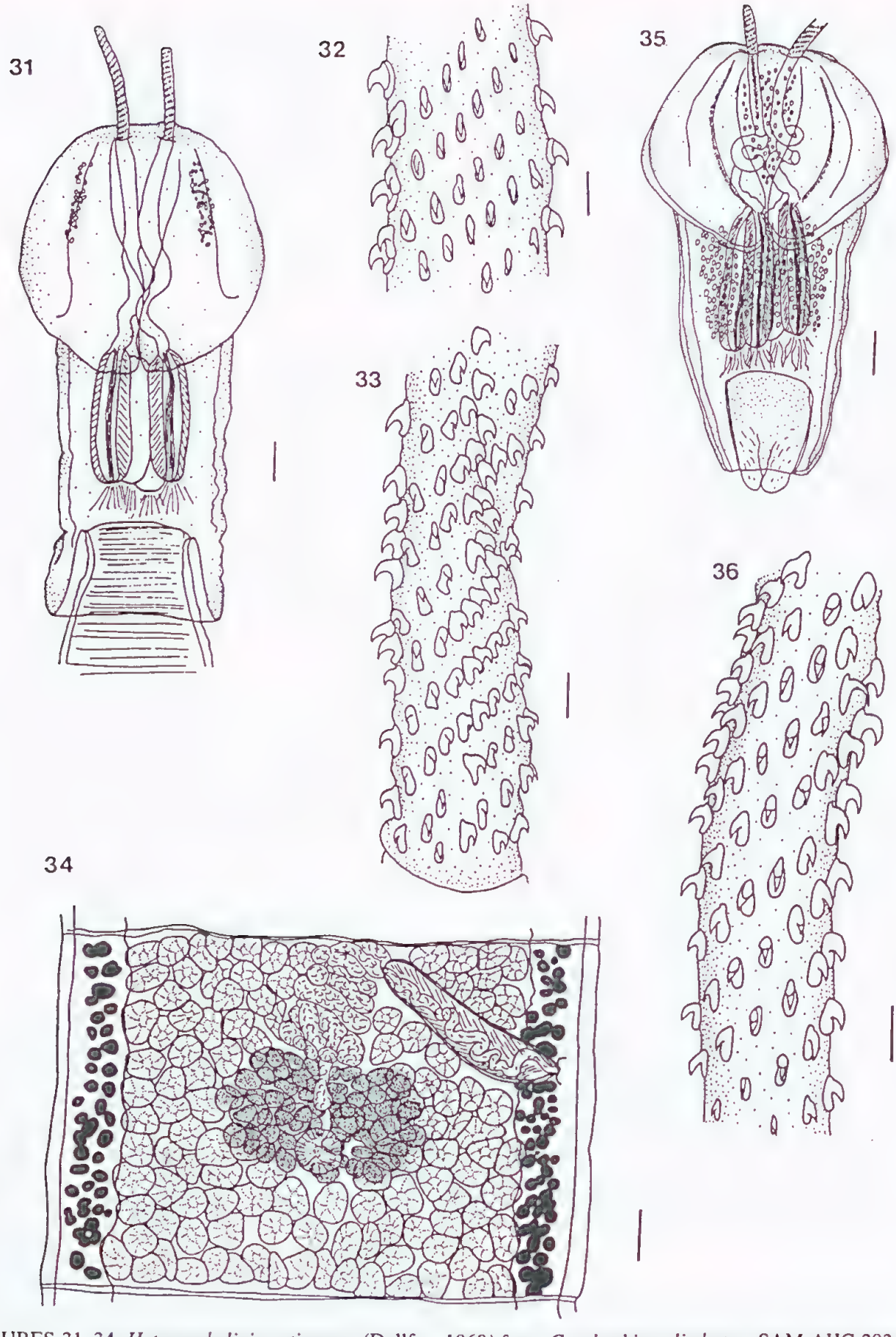
From *Carcharhinus amblyrhynchoides* (Whitley, 1934): 2 adults from spiral valve, Tommy Cut Mouth, Northern Territory, coll. B. G. Robertson, 10.ix.1986 (SAM AHC 28321).

From *Carcharhinus* sp: 3 adults from spiral valve, Queensland, coll. B. G. Robertson, Oct. 1985 (SAM AHC 18322).

From *Sarda australis* (Macleay, 1881): 9 postlarvae from gill arches, Heron Island, Queensland, coll. M. K. Jones, Jan. 1991 (QM G 218042–218046).

Description

Adult: SL = 1650, 1500 (Fig. 31); SW = 790, 770; pbo = 820, 820; pv = 690, 610; pb = 480, 430; ppb = 110, 80; vel = 330, 320; BL = 455 (440–480), 425 (420–430); BW = 133 (130–140), 120 (118–122); BR = 3.4:1, 3.6:1; SP = 1.7:1.4:1, 1.9:1.4:1. Tentacles long, slender (TL = 520, 560), TSW = 42.5–47.5, 45.0–55.0; TW basal 45–50, 42.5–45; TW apical 25–30, 27.5–32.5; basal tentacular swelling absent. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths visible in one specimen. Retractor muscles originate at bases of bulbs. Tentacular armature homeoacanthous, heteromorphous, no characteristic basal armature present (Figs 32–33). Hooks rosethorn-shaped, increase in size towards metabasal part of



FIGURES 31–34. *Heteronybelinia estigmena* (Dollfus, 1960) from *Carcharhinus limbatus*. SAM AHC 28318–20. **31.** Scolex. **32.** Metabasal armature. **33.** Basal armature. **34.** Mature proglottid. Scale bars: Figure 31, 150 µm; Figures 32–33, 15 µm; Figure 34, 100 µm. FIGURES 35–36. *H. estigmena* from *Sarda australis*. QM G 218042–46. **35.** Scolex. **36.** Basal armature. Scale bars: Figure 35, 150 µm; Figure 36, 15 µm.

tentacle. Hook form varies from compact and rosethorn-shaped (bothridial) to smaller rosethorn-shaped hooks with elongated base (antibothridial). Hook size, metabasal, L = 11.3–12.5; B = 9.3–10.8 (bothridial) and L = 9.3–10.8; B = 10 (antibothridial), with largest hooks L = 13.8–15.0; B = 10.0–12.5 (bothridial); hooks diminish in size towards apical part of tentacle. Hook size in basal region L = 7.5–8.8; B = 6.3–10.0 (bothridial) and L = 5.0–7.5; B = 6.3–7.5 (antibothridial); hsr = 6–7. Strobila 56 mm long, maximum width 1250, about 280 acraspedote segments (Fig. 34). First segments behind velum short, enlarge in size, mature segments wider than long, from 500 x 840 to 700 x 1030. In mature segments, genital atrium ventro-submarginal, in anterior third of segment; genital pores alternate irregularly. Cirrus sac elongated, 300–450 x 80–110 (n = 5), length:width ratio 3.8–4.1:1, directed anteromedially, sac thin-walled; cirrus unarmed and coiled within sac. Ovary median, follicular, ovarian lobes 200–230 (length) x 110–170 (width), Mehlis' gland 80 in diameter, seminal receptacle 110 x 70; testes of variable shape, 60–80 x 30–60 (n = 5) in diameter, arranged in single layer; testes number 106–126 (n = 5) per segment, encircle female genital complex and occupy entire medulla except for region of female genital complex and anterior to it; 7–9 testes anterior to cirrus sac. Vitelline follicles 20–40 in diameter; egg diameter 20–25; ventral osmoregulatory canals along margins of cortex, 6 in diameter.

Postlarva: SL = 1650, 1500 (Fig. 35); SW = 790, 770; pbo = 820, 820; pv = 690, 610; pb = 480, 430; ppb = 110, 80; vel = 330, 320; BL = 460 (430–470), 445 (440–450); BW = 115 (110–120), 120 (118–122); BR = 4.0, 3.7; SP = 1.7:1.4:1, 1.9:1.4:1. Tentacles long, slender (TL = 550–580), TSW = 40–45; TW basal = 35–40, TW metabasal and apical = 30–40; basal tentacular swelling absent. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths present. Retractor muscles originate at base of bulbs. Tentacular armature homeoacanthous, heteromorphous; characteristic basal armature absent. Hook shape varies from compact, rosethorn-shaped (bothridial) to smaller rosethorn-shaped hooks with elongated base (antibothridial); hooks increase in size towards metabasal part of tentacle on bothridial and antibothridial surface (Fig. 36). Hook size, metabasal, L = 12.5–15.0, B = 11.8–13.3 (bothridial) and L = 11.3–12.5; B = 7.5–10.0 (antibothridial); basal L = 7.5–10.0; B = 8.8–11.3 (bothridial) and L = 5.0–7.5; B = 6.3–8.8 (antibothridial); hsr = 6–7.

Remarks

Heteronybelinia estigmena (Dollfus, 1960) is a well-described tentaculariid. Palm (1995) reported this cestode as *Nybelinia alloiotica* Dollfus, 1960 from *Carcharhinus limbatus* in the Atlantic, the same host species as in the present study. Palm (1999) and Palm and Walter (2000) provided additional information on the species. *H. estigmena* resembles *H. perideraeus* (Shipley & Hornell, 1906) and *H. elongata* (Shah & Bilquees, 1979) known from the coast of India. However, the hook size increases on both the bothridial and antibothridial tentacle surfaces in *H. estigmena*. In *H. elongata*, the hook size increases on the antibothridial tentacle surface only (Palm & Walter 1999), while in *H. perideraeus*, the basal and metabasal hook sizes are the same (Palm 1999). The present study represents the first record of the cestode from Australian waters. *Carcharhinus amblyrhynchoides* and *Sarda australis* represent new hosts for the species.

Heteronybelinia pseudorobusta sp. nov.
(Figs 37–41)

Types

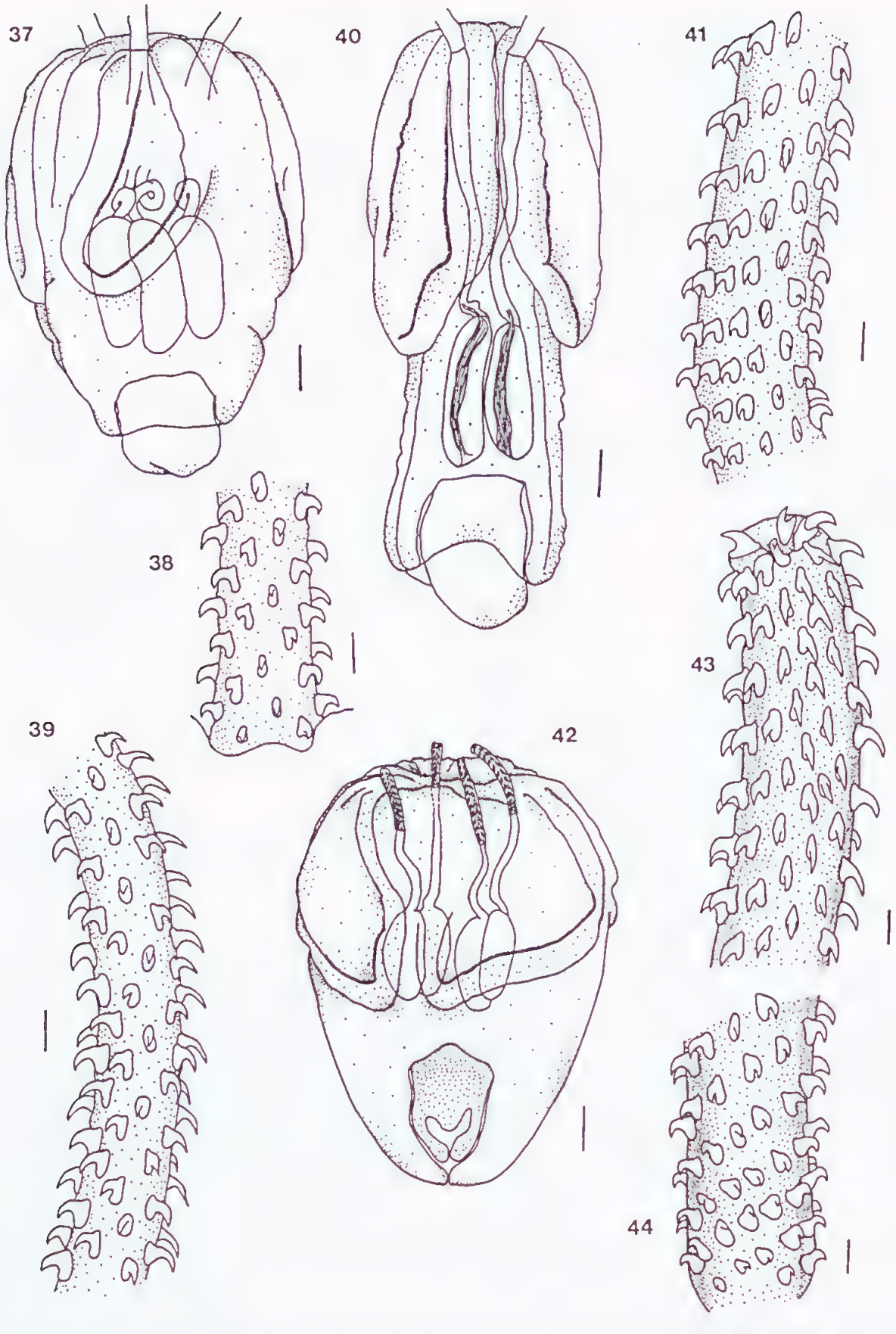
Holotype from gills of *Lepidotrigla modesta* Waite, 1899, Port Phillip Bay, Victoria, coll. R. Norman, 17.iii.1989 (SAM AHC 28341); 3 paratypes, same data (SAM AHC 28342).

Material examined

Types.

Description

Small form (holotype and one paratype): SL = 960 (Fig. 37), 730; SW = 660, 550; pbo = 570, 450; pv = 420, 270; pb = 285, 290; app = 220, 160; vel = 70, 60; BL = 280 (275–285), 298 (275–315); BW = 150 (145–155), 139 (110–165); BR = 1.9:1, 2.1:1; SP = 2.0:1.5:1, 1.6:0.9:1. Tentacle sheaths sinuous to spirally coiled; TSW = 45.0–47.5, 45.0–50.0; TW basal 45.0–50.0, metabasal 40.0–45.0, basal tentacular swelling absent. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths not seen, retractor muscles originate at base of bulbs. Tentacular armature homeoacanthous, heteromorphous, characteristic basal armature absent (Fig. 38). Hook form changes from compact, rosethorn-shaped



FIGURES 37–41. *Heteronybelinia pseudorobusta* sp. nov. from *Lepidotrigla modesta*. **37**. Scolex of small form SAM AHC 28314. **38**. Basal armature. **39**. Metabasal armature. **40**. Scolex of large form SAM AHC 28342. **41**. Metabasal armature. Scale bars: Figure 37, 100 µm; Figures 38–39, 20 µm; Figure 40, 100 µm; Figure 41, 15 µm. FIGURES 42–44. *Mixonybelinia cribbi* sp. nov. from *Platycephalus arenarius*. Holotype, QM G 218047. **42**. Scolex. **43**. Metabasal armature. **44**. Basal armature. Scale bars: Figure 42, 200 µm; Figures 43–44, 20 µm.

(bothridial) to more slender hooks with stout base (antibothridial) (Fig. 39). Hook size in metabasal armature ranged between L = 13.8–16.3; B = 11.3–13.8 (bothridial) and L = 16.3–17.5; B = 10.0–11.3 (antibothridial), hooks of basal part of tentacle smaller, between L = 10.0–11.0; B = 11.3–9.0 (bothridial) and L = 11.3–12.5; B = 8.8–10.0 (antibothridial), continuously increasing towards the tip; hsr = 6–7.

Large form (2 paratypes): SL = 1310 (Fig. 40); 1310; SW = 600, 620; pbo = 810, 780; pv = 580, 500; pb = 390, 380; app = 330, 330; vel = 280, 310; BL = 376 (360–390), 321 (310–330); BW = 124 (115–140), 121 (105–135); BR = 3.0:1; SP = 2.1:1.5:1. Tentacle sheaths sinuous to spirally coiled; TSW = 40–45, 42.5–47.5; TW basal 45.0–47.5, metabasal 30.0–35.0, 30.0–35.0. Basal tentacular swelling absent, prebulbar organs absent, muscular rings around basal part of tentacle sheaths not seen. Retractor muscles originate at base of bulbs. Tentacular armature homeoacanthous, heteromorphous, characteristic basal armature absent. Hooks change from compact and rosethorn-shaped (bothridial) to more slender hooks with a stout base (antibothridial) (Fig. 41). Hook size in metabasal armature between L = 12.5–14.5; B = 11.3–12.5 (bothridial) and L = 14.5–15.5; B = 8.8–10.0 (antibothridial), hooks of basal part of tentacle small, between L = 8.8–10; B = 7.5–9.0 (bothridial) and L = 6.3–8.8; B = 6.3–7.5 (antibothridial), increasing in size towards tip; hsr = 6–7.

Remarks

Heteronybelinia pseudorobusta sp. nov. is characterised by a heteromorphous tentacular armature consisting of small basal hooks increasing in size towards the metabasal region. The hook shape varies from rosethorn-shaped to slender hooks with a stout base on different surfaces of the tentacle. Small basal hooks which gradually increase in size towards the metabasal armature are characteristic of *Heteronybelinia robusta* (Linton, 1890). However, in contrast to *H. pseudorobusta* sp. nov., *H. robusta* has minute basal hooks, less than 5 in length, and the hook form is uniform along the tentacle. In the present specimens, the basal hook size is larger and the hook form is rosethorn-shaped. All other *Heteronybelinia* species differ in having a different hook shape or arrangement. Thus, the present specimens belong to a new species, *H. pseudorobusta* sp. nov., the name being derived from the similarity in hook arrangement to *H. robusta* (Linton, 1890). *H. pseudorobusta* is a species without a characteristic basal armature and with basal hook sizes smaller than metabasal hook sizes. It therefore belongs to the *Heteronybelinia* species subgroup 'Aa' in Palm (1999).

Heteronybelinia pseudorobusta sp. nov. occurred in two different size groups, those smaller than 1 mm and those larger than 1.3 mm, respectively. Thus, the present description is an example of intraspecific morphological variability within species of *Heteronybelinia*, apparently due to scolex contraction during fixation.

Genus *Mixonybelinia* Palm, 1999

Mixonybelinia beveridgei (Palm, Walter, Schwerdtfeger & Reimer, 1997)

Material examined

From *Macruronus novaezelandiae* (Hector, 1871): 1 postlarva, west coast of Tasmania, coll. K. Sewell, June 1986 (QM G 218067).

Description

SL = 3200; SW = 2750; pbo = 1750; pv = 850; pb = 1300; ppb = 80; vel = 950; app = 730; BL = 1226 (1150–1310); BW = 290 (240–320); BR = 4.2:1; SP = 1.3:0.7:1. Tentacle sheaths sinuous to spirally coiled; TSW = 100–130. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths not seen. Retractor muscles originate in basal parts of bulbs. Basal tentacular swelling absent; TW basal = 110–120, TW metabasal = 115–135. Metabasal armature homeoacanthous, heteromorphous, characteristic homeomorphous basal armature consisting of about 6–7 rows of slender hooks with elongated shaft, stout base and strongly recurved at tip (L = 31.3–40.0, B = 18.8–27.5). Metabasal hooks strongly recurved, rosethorn-shaped with large base on antibothridial surface: L = 50.0–52.5, B = 37.5–42.5; slender falcate hooks with stout base on bothridial surface: L = 55.0–60.0, B = 27.5–30.0; hsr = 6.

Remarks

The present specimen is characterised by a homeomorphous basal armature of 6–7 rows of hooks and a heteromorphous metabasal armature of massive hooks, thus corresponding in form and size with specimens of *M. beveridgei* described from African waters by Palm et al. (1997). Other features are the large scolex size as well as TSW and TW. However, due to the contracted nature of

the scolex of the current specimen, values for scolex and bulb proportions as well as the tentacle sheaths differed, indicating the variability of these characters due to the degree of contraction of the scolex. The present finding represents a new host and locality record for *M. beveridgei*.

Mixonybelinia cribbi sp. nov.
(Figs 42–44)

Types

Holotype, postlarva from *Platycephalus arenarius* Ramsay & Ogilby, 1886, Heron Island, Queensland, coll. J. Reddick, Jan. 1997 (QM G 218047).

Material examined

Types.

Description

Scolex craspedote, SL = 2920 (Fig. 42); SW = 2200; pbo = 1700; pv = 1020; pb = 730; ppb = 220; vel = 760; app = 780; BL = 615 (600–630); BW = 232 (220–240); BR = 2.7:1; SP = 2.3:1.4:1. Tentacle sheaths short; TSW = 50–65. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths not seen. Retractor muscles originate in basal part of bulbs. Basal tentacular swelling absent; TW basal = 70–75, TW metabasal = 65–75. Homeoacanthous, heteromorphous metabasal armature consisting of rosethorn-shaped hooks on bothridial and more slender hooks with stout base on antibothridial surface (Fig. 43); characteristic homeomorphous basal armature (Fig. 44) consisting of about 4 rows of slender hooks with enlarged base and strongly recurved at tip (L = 12.5–17.5, B = 10.0–15.0 to 8.8–11.3). Metabasal hooks strongly recurved, rosethorn-shaped with large base on antibothridial surface: L = 20.0–22.5, B = 18.8–21.3; slender falcate with stout base along bothridial surface: L = 21.3–23.7, B = 15.0–17.5; hsr = 6–7.

Remarks

M. cribbi sp. nov. resembles *M. beveridgei* in scolex size as well as in tentacular armature. Both species have a homeomorphous basal and a heteromorphous metabasal armature as well as a large scolex about 3 mm in length. However, *M. cribbi* sp. nov. is clearly distinguishable from *M. beveridgei* by having only 4 rows of basal hooks compared with 6 in *M. beveridgei*. In addition, the hooks have a distinctly enlarged base in *M. cribbi* and all hooks are smaller (20–24 in *M. cribbi* compared with 46–68 in *M. beveridgei*, see Palm et al. 1997). The new species was named after Dr T. H. Cribb, Department of Parasitology, University of Queensland, Australia.

Mixonybelinia edwinlintoni (Dollfus, 1960)
(Figs 45–53)

Material examined

From *Sphyrna lewini* (Griffith & Smith, 1843): 10 adults from stomach, Flat Top Island, Queensland, coll. B. G. Robertson, 23.x.1985 (SAM AHC 28324); 1 adult, Geraldton, Western Australia, coll. B. G. Robertson, 27.xi.1986 (SAM AHC 28323).

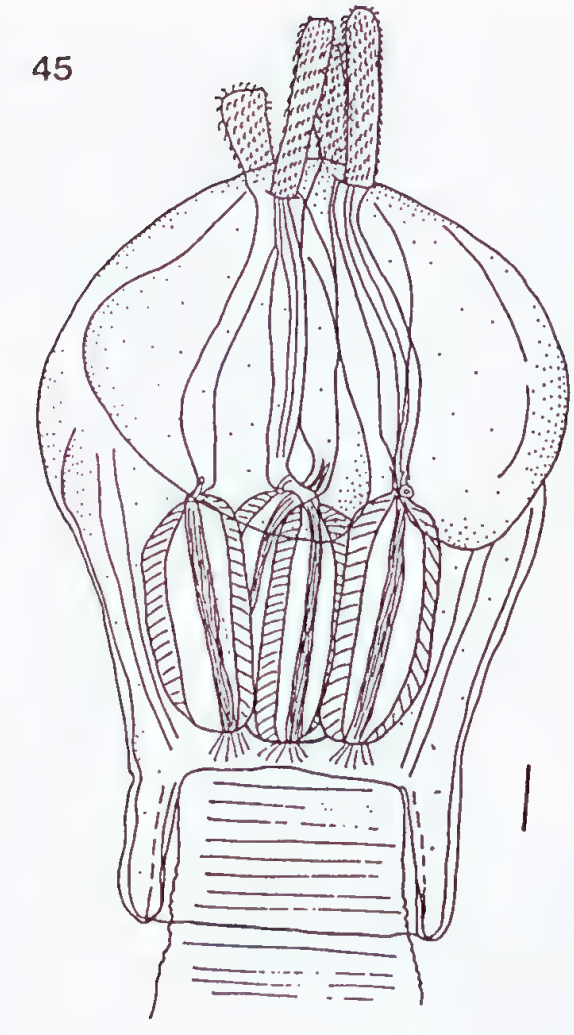
From *Rhynchobatus djiddensis* (Forsskål, 1775): 9 postlarvae from spiral valve, Moreton Bay, Queensland, coll. S. Butler, 17.iv.1980 (QM G 218048–218060).

From *Carcharhinus melanopterus* (Quoy & Gaimard, 1824): 1 postlarva, (QM G 4813).

Description

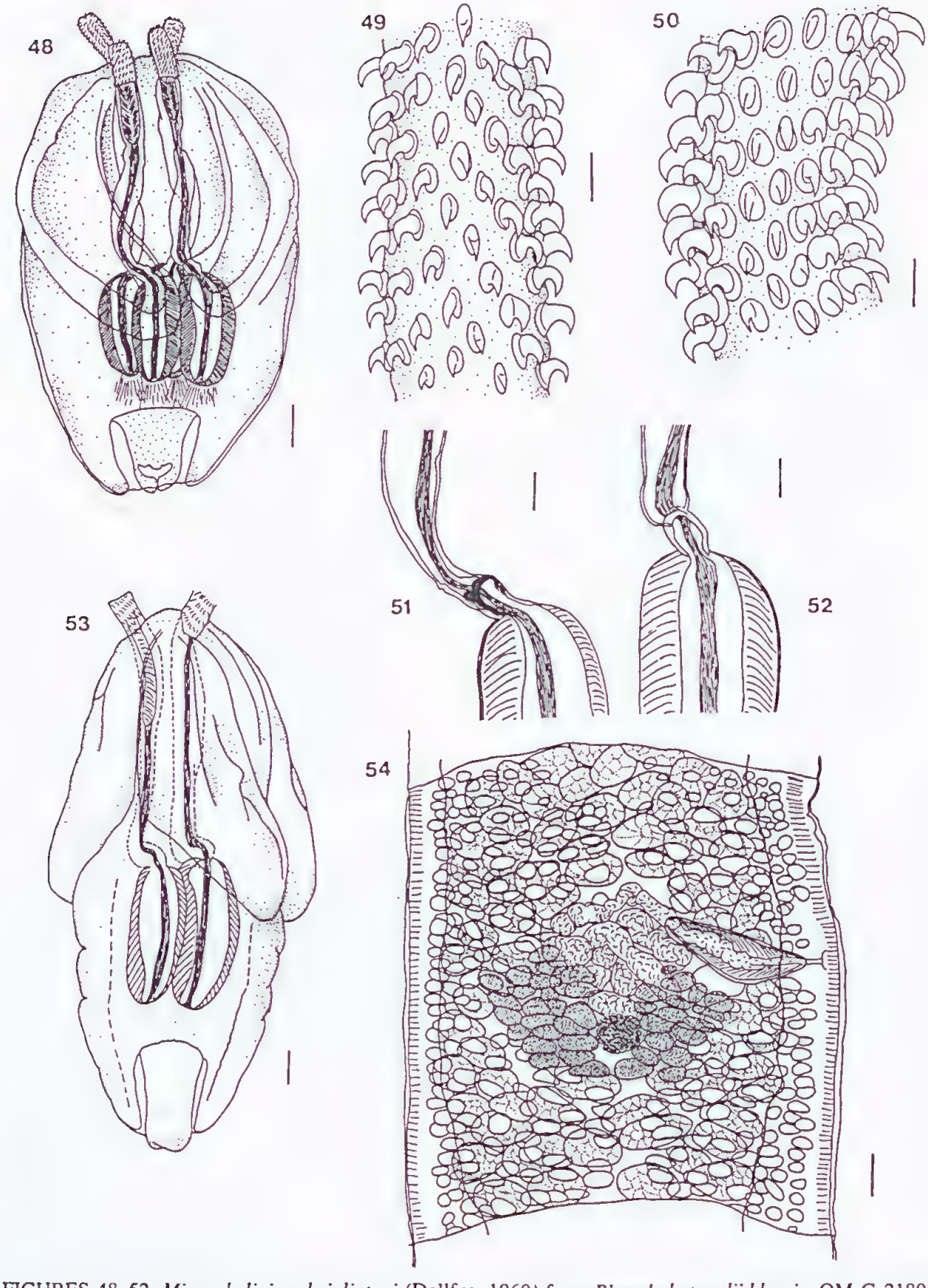
Adults: SL = 1780, 1620 (Fig. 45); SW = 1210, 1160; pbo = 1000, 1000; pv = 760, 690; pb = 620, 530; ppb = 60, 30; vel = 340, 330; BL = 585, 520, 520, 530, 490, within single specimen 580–600; BW = 235 (230–240); BR = 2.5:1; SP = 1.6:1.2:1. Tentacles robust; tentacle sheaths straight, TSW = 50–90. Prebulbar organs absent, muscular rings around basal part of tentacle sheaths visible in some specimens. Retractor muscles originate in basal part of bulbs: basal tentacular swelling absent; TW basal = 60–65; TW metabasal = 70–75. Metabasal armature homeoacanthous, heteromorphous (Fig. 46); characteristic homeomorphous basal armature consisting of about 10 rows of slender falciform hooks (Fig. 46). Metabasal hooks strongly recurved along antibothridial surface: L = 20.0–25.0; B = 17.8–21.3; slender falcate hooks along bothridial surface: L = 32.5–35.0; B = 15.0–17.5. Basal hook size: L = 17.5–20.0, B = 10.0–13.8; hsr basal: 7–8; hsr metabasal: 8–9.

Largest cestode 53 mm, maximum width 880; 560 segments; strobila craspedote, velum irregularly scalloped, up to 50 wide; pre-mature (no ovary) segments (Fig. 47) wider than long, 100 x 1020 to 120 x 1020. Genital pores submarginal, in first third of segment; alternate irregularly. Cirrus sac elongate, 280–330 x 45–60 (n = 5) in mature segments, length:width ratio 5.7:1 (4.7–7.1:1), distal pole directed



FIGURES 45–47. *Mixonybelinia edwinlintoni* (Dollfus, 1960) from *Sphyrna lewini*. SAM AHC 28324. **45**. Scolex. **46**. Basal and metabasal armature. **47**. Pre-mature proglottid. Scale bars: Figure 45, 150 µm; Figure 46, 25 µm; Figure 47, 60 µm.

anteromedially, nearly reaching anterior end of segment; cirrus unarmed; internal and external seminal vesicles absent. Vas deferens coiled, extends to midline of segment, then posteriorly towards female genital complex. Testes in two groups, not confluent posterior to ovary, 80 (poral) and 116 (antiporal) (estimated), 30–40 in size (central), smallest testes at margin of medulla, external to osmoregulatory canal (15–25), distributed in 2–3 layers, extend anterior to cirrus sac; seminal receptacle present. Small vitelline follicles encircle medulla, between 24 longitudinal muscle bands. Osmoregulatory canals 5 and 20 in diameter.



FIGURES 48–52. *Mixonybelinia edwinlintoni* (Dollfus, 1960) from *Rhynchobatus djiddensis*. QM G 218048–60. **48.** Scolex. **49.** Basal armature. **50.** Metabasal armature, 20 rows from the base. **51–52.** Bulb with tentacle sheath. Scale bars: Figure 48, 150 µm; Figures 49–50, 25 µm; Figures 51–52, 50 µm. FIGURE 53. *M. edwinlintoni* from *Carcharhinus melanopterus*. QM G 4813. Scolex. Scale bar: 100 µm. FIGURE 54. *Kotorella pronosoma* (Stossich, 1901) from *Dasyatis fluviorum*. QM G 218063. Mature proglottid. Scale bar: 50 µm.

Postlarvae (from *R. djiddensis):* SL = 1600, 1500 (Fig. 48); SW = 1000, 1180; pbo = 1020, 950; pv = 680, 600; pb = 420, 470; ppb = 140, 120; vel = 280, 250; app = 280, 250; BL = 390 (370–410), 430 (410–440); BW = 188 (180–190), 163 (150–180); BR = 2.1:1, 2.6:1; SP = 2.4:1.6:1; 2.0:1.3:1. Tentacle sheaths straight, TSW = 40–85. Prebulbar organs absent, muscular rings and thickenings around basal part of tentacle sheaths visible in some specimens (Figs 51, 52). Retractor muscles originate in basal part of bulbs (Fig. 48); basal tentacular swelling absent; TW basal = 80, 80; TW metabasal = 70, 80. Homeomorphous basal armature of about 10 rows of slender falciform hooks (Fig. 49), metabasal armature homeoacanthous, heteromorphous (Fig. 50). Metabasal hooks strongly recurved along antibothridial surface: L = 22.5–25.0; B = 17.5–20.0; slender falcate hooks along bothridial surface: L = 23.8–26.3; B = 12.5–15.0. Basal hook size: L = 17.5–20.0, B = 12.5–13.8; hsr basal: 7–8; hsr metabasal: 8–9.

*Postlarva (*from *C. melanopterus)*: SL = 1648 (Fig. 53); SW = 848; pbo = 912; pv = 768; pb = 432; ppb = 96; app = 320; vel = 240; BL = 429 (411–443); BW = 171 (158–177); BR = 2.5:1; SP = 2.1:1.8:1. Tentacles massive (TL = 630), TSW = 68–70; TW basal 77–80, TW metabasal 85–89, basal tentacular swelling absent. Prebulbar organs absent; muscular rings around basal part of tentacle sheaths not visible; retractor muscles originate at base of bulbs. Tentacular armature homeoacanthous, heteromorphous; characteristic basal armature absent. Hooks diminish in size towards base; hook shape varies from compact rosethorn-shaped (antibothridial) to slender rosethorn-shaped hooks with stout base (bothridial). Hook size, metabasal, rows 16–17, L = 23.7–25.2; B = 14.2–15.8 (antibothridial) and L = 25.2–26.8; B = 9.5–12.0 (bothridial); basal L = 17.4–19.0; B = 14.2–15.8 (antibothridial) and L = 17.4–19.0; B = 12.6–14.2 (bothridial); hsr = 7–8.

Remarks

Palm and Walter (2000) redescribed *Mixonybelinia edwinlintoni* (Dollfus, 1960) illustrating a distinctly different basal and metabasal armature within the species. While the metabasal armature has different hooks on the bothridial and antibothridial tentacle surface, the hooks of the basal armature appear to be homeomorphous. The arrangement of the hooks, together with their characteristic shape, and the scolex shape, indicate that the present specimens belong to *M edwinlintoni. Rhynchobatus djiddensis* and *Carcharhinus melanopterus* represent two new hosts for the species.

Prior to the re-description of *M. edwinlintoni*, Palm (1999) erected *Heteronybelinia heteromorphi*, a species which is also very similar to the present material. In *H. heteromorphi* the basal armature is heteromorphous, while in *M. edwinlintoni* it is homeomorphous. In addition, the type material of *H. heteromorphi* was described as being acraspedote while *M. edwinlintoni* is craspedote (Fig. 47). Interestingly, both species occur within the same host genus, *Sphyrna.* Other characters such as the massive scolex form, the heteromorphous metabasal armature, and the testis sizes are similar in both species. The type material of *H. heteromorphi* needs to be re-examined to confirm the differences between the species.

Mixonybelinia southwelli (Palm & Walter, 1999)

Material examined

From *Makaira indica* (Cuvier, 1832): 1 postlarva, Cape Bowling Green, Queensland, coll. P. Speare, 18.ix.1987 (QM G 218061).

From *Chaerodon venustus* (DeVis, 1885): 1 postlarva, Heron Island, Queensland, coll. R. Bray, 30.i.1991 (QM G 218062).

Description

SL = 2000, 1550; SW = 1050, 690; pbo = 1030, 890; pv = 850, 660; pb = 440, 590; ppb = 40; vel = 450, 220; app = 670, 270; BL = 411 (400–425), 548 (520–580); BW = 153 (140–165), 153 (140–170); BR = 2.7:1, 3.6:1; SP = 2.3:1.9:1, 1.5:1.1:1. Tentacle sheaths spirally coiled; TSW = 55–60, 50–60. Prebulbar organs absent, muscular rings around the basal part of tentacle sheaths not seen; retractor muscles originate in basal part of bulbs; tentacular swelling absent; TW basal = 50.0–55.0, 47.5–55.0, TW metabasal = 35–47, 30–35. Armature homeoacanthous, heteromorphous; characteristic basal armature consisting of about 14–16 rows. Antibothridial metabasal hooks massive, rosethorn-shaped, L = 15.0–17.5, 15.0–16.3, B = 13.7–15.0, 15.0–17.5; bothridial hooks more slender and slightly curved with stout base, L = 18.7–20.0, 17.5–20.0, B = 11.3–12.5, 11.3–13.8. Basal armature homeomorphous, hooks falciform with stout base and strongly recurved tip, L = 15.0–22.5,

18.8–21.3; B = 7.5–8.7, 7.0–8.0; hsr basal = 6–7, hsr metabasal = 5–6.

Remarks

The postlarva from *Chaerodon venustus*, collected at Heron Island, is similar in scolex size and proportions, armature pattern and hook sizes to those described for *M. southwelli* by Palm and Walter (1999). Differences in scolex measurements of the specimen from *Makaira indica* are probably due to the shrunken condition of that specimen. The change in armature pattern from falciform basal hooks to heteromorphous rosethorn-shaped metabasal hooks is characteristic for *M. southwelli*. The distribution of the species is extended to eastern Australian waters, and *Makaira indica* and *Chaerodon venustus* represent new hosts for the species.

Genus *Kotorella* Euzet & Radujkovic, 1989

Kotorella pronosoma (Stossich, 1901)
(Fig. 54)

Material examined

From *Dasyatis fluviorum* Ogilby, 1908: 2 adults, Moreton Bay, Queensland, coll. S. Butler, 26.ix.1980 (QM G 218063–218064).

Description

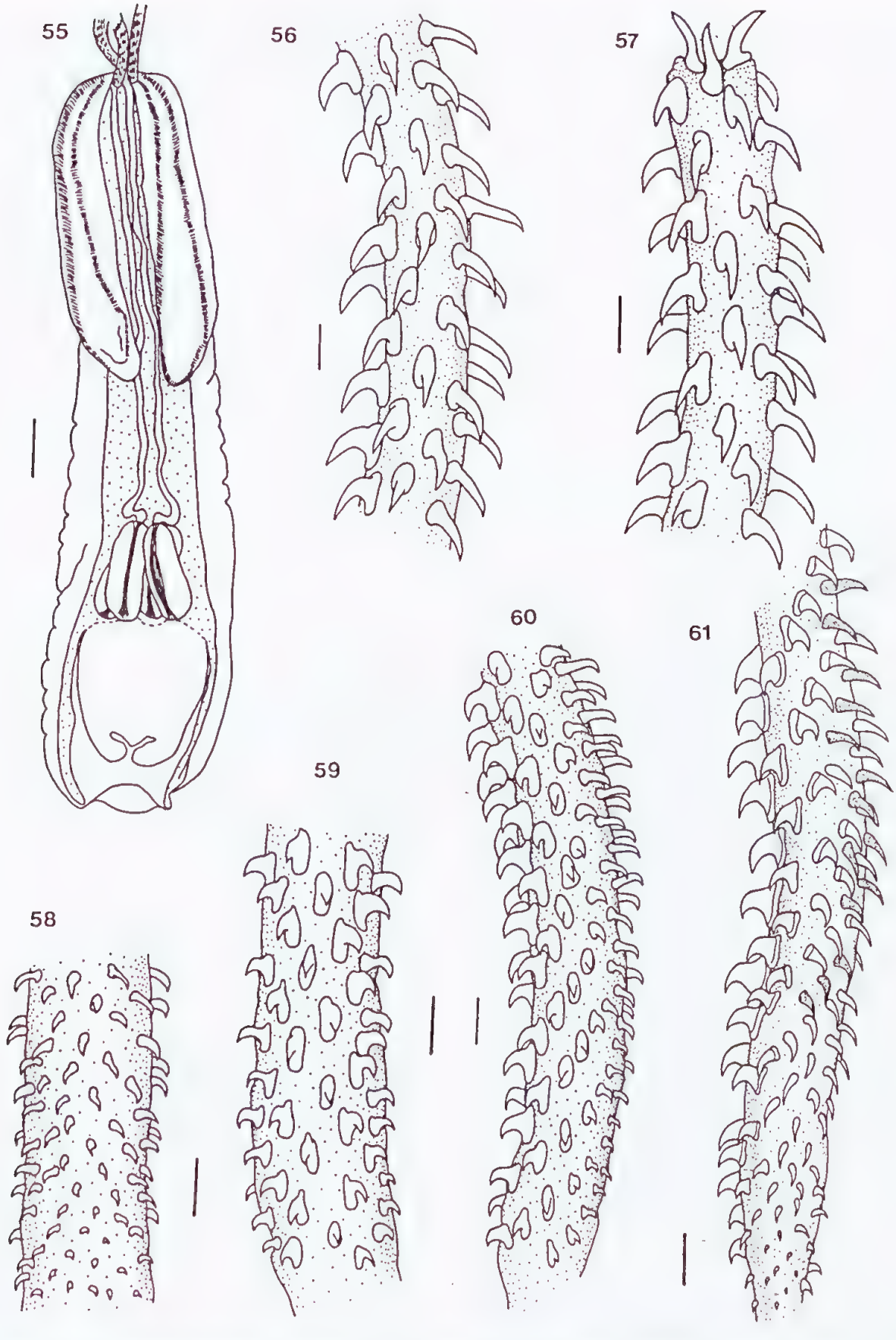
SL = 570, 660; SW = 200, 200; pbo = 400, 390; pv = 385, 510; pb = 80, 85; vel = 110, 80; BL = 71 (70–73), 78 (71–88); BW = 39.4 (37.5–40.0), 40.0 (35.3–45.0); BR = 1.8:1, 2.0:1; SP = 5.0:4.8:1, 4.6:6.0:1. TW basal = 17.5, 22.5. Basal tentacular swelling absent. Tentacle sheaths straight; TSW = 11.3–15.0, 5.5–15.0. Prebulbar organs and muscular rings around basal part of tentacle sheaths absent; retractor muscles originate in basal part of bulbs. Tentacular armature homeoacanthous, heteromorphous; basal hooks on bothridial surface L = 6.3–7.5, 6.3–7.5, B = 5.0–6.0, 5.0–6.0, smallest hooks on antibothridial surface L = 2, increasing in size towards metabasal region. Small, incomplete worms to 15 mm long, maximum width 570; 90 segments. Strobila acraspedote; pre-mature segments 30 x 110 – 260 x 360, mature segments longer than wide or wider than long, 480 x 430 to 550 x 620 (Fig. 54). In second specimen, mature segments 500 x 440 to 550 x 650, and pre-gravid (with some eggs) segments 320 x 710 to 750 x 620. Genital pores submarginal, 210 from anterior margin; alternate irregularly. Cirrus sac elongate, 150–250 x 30–60 (n = 5) in mature segments, length:width ratio 4.4:1 (4.0–5.0:1); cirrus unarmed; internal and external seminal vesicles absent. Vas deferens in large coils, extends to midline of segment, then posteriorly towards female genital complex. Testes 86 (81–100) in number, 45–85 in size (central), smallest testes 20–50 (peripheral), distributed in single layer, confluent posterior and anterior to ovary. Ovary median, ovarian lobes 110–200 x 100–150; Mehlis' gland small, situated between ovarian lobes. No vitelline follicles in centre of the segment, follicles 33 (25–45) in diameter. No uterus observed, spherical eggs appear in parenchyma, egg diameter 22 (15–40).

Remarks

The morphology of *Kotorella pronosoma* (Stossich, 1901) is summarised by Euzet and Radujkovic (1989), Palm and Walter (1999) and Palm and Overstreet (2000). The present specimens from Moreton Bay correspond in scolex size and proportions as well as in the tentacular armature with the other described specimens. The sole difference noted was in testis number which exceeded 80 per segment in the specimens described. The species has previously been found in rays such as *Aetobatus narinari* (Euphrasen, 1790) (see Palm & Overstreet 2000), *Himantura imbricata* (Bloch & Schneider, 1801), *Rhynchobatus djiddensis* (see Shipley & Hornell 1906; Palm & Walter 1999) and *Dasyatis pastinaca* (Linnaeus, 1758) (see Euzet & Radujkovic 1989; Palm & Walter 2000). *Dasyatis fluviorum* represents a new host record, and the range of distribution is extended to eastern Australian waters. The present finding suggests a cosmopolitan distribution for the species. Previously, the nearest known occurrence of this cestode to Australia was from the Java Sea under the name *Nybelinia narinari* (MacCallum, 1917), now a synonym of *Kotorella pronosoma* (see Palm & Overstreet 2000).

Kotorelliella gen. nov.

Diagnosis: Tentacles elongate, slender; retractor muscle originates at base of bulbs. Metabasal tentacular armature homeoacanthous, heteromorphous; hooks on bothridial surface uncinate becoming slender towards antibothridial surface. Basal hooks heteromorphous; characteristic basal armature present, arranged in a heteroacanthous atypica pattern with



FIGURES 55–61. *Kotorelliella jonesi* gen. et sp. nov. from *Taeniura lymma*. Holotype, QM G 218065. **55**. Scolex. **56–57**. Metabasal and apical armature, external view. **58**. Basal armature, bothridial view. **59**. Basal armature, antibothridial view. **60–61**. Basal towards metabasal armature, external view. Note the interpolated hooks as in Fig. 61. Scale bars: Figure 55, 150 μm; Figures 56–61, 10 μm.

interspersed hooks on the antibothridial tentacle surface. Hooks solid. Strobila unknown.

Type-species: *Ko. jonesi* sp. nov.

Kotorelliella jonesi sp. nov.
(Figs 55–61)

Types

Holotype, 1 postlarva from the spiral valve of *Taeniura lymma* (Forsskål, 1775), Heron Island, Queensland, coll. I. Beveridge & M. K. Jones, 11.vii.1998 (QM G 218065).

Material examined

Holotype.

Description

Scolex compact, 4 elongated bothridia, with hook-like microtriches along bothridial borders. Posterior margins of bothridia free, not fused with peduncle. SL = 1910 (Fig. 55); SW = 390; pbo = 800; pv = 1140; pb = 260; vel = 460; BL = 259 (250–265); BW = 82.5 (80–85); BR = 3.1:1; SP = 3.1:4.4:1. Tentacles long and slender; TW basal and metabasal = 21.2–23.8; TW apical = 17.5–20; basal tentacular swelling absent. Tentacle sheaths straight; TSW = 15.0–17.7. Prebulbar organs and muscular rings around basal part of tentacle sheaths absent; retractor muscles originate in basal part of bulbs. Metabasal (Fig. 56) and apical (Fig. 57) armature homeoacanthous, heteromorphous. Rosethorn-shaped hooks with anterior extension of base cover bothridial tentacle surface (L = 13.5–15.0, B = 7.5–10.0); antibothridial surface with slender spiniform hooks, recurved at tip (L = 15.0–17.5, B = 5.0–6.3); hooks decrease in size towards apical armature; hook shape remains constant (bothridial: L = 11.3–13.7, B = 10.0–11.2; antibothridial: L = 12.5–13.7, B = 4.5–5.5). Basal armature (Figs 58–61) with additional hooks interspersed on antibothridial surface; hook pattern heteroacanthous atypica, consisting of about 5 rows of hooks on bothridial (Fig. 59) and 9–10 rows on antibothridial (Fig. 58) tentacle surface; basal hooks on bothridial surface L = 6.3–10.0, B = 6.3–8.8, on antibothridial surface L = 2.0–10.0, B = 1.5–3.8, continuously increasing in size from base of tentacle towards metabasal armature (Figs 60–61).

Remarks

The holotype of *Kotorelliella jonesi* gen. et sp. nov. has a unique form of armature within the Tentaculariidae, changing from a homeoacanthous, heteromorphous hook pattern with rosethorn-shaped hooks in the metabasal armature to a heteroacanthous atypica hook pattern in the basal armature. The size of hooks in the basal and apical regions is smaller than in the metabasal region.

On the basis of the scolex morphology, *Ko. jonesi* sp. nov. appears to be similar to *Kotorella pronosoma*. Both species have an elongated scolex, four elongated and slender bothridia with free margins, and short oval bulbs. In both species, the metabasal armature is heteromorphous, with hooks changing from uncinate on the bothridial surface to elongate on the antibothridial surface. Both species have a band of hook-like microtriches along bothridial borders, which are clearly visible using light microscopy. Such a microthrix pattern is characteristic for tentacullariid trypanorhynch cestodes.

The basal armature of *K. pronosoma* is homeoacanthous, but that of *Ko. jonesi* sp. nov. is unusual, having additional hooks interspersed between the oblique spirals of hooks. Thus, the basal tentacular armature is heteroacanthous atypica. The basal region is homeoacanthous in *Nybelinia*, *Heteronybelinia* and *Mixonybelinia*, but in *Tentacularia*, the bothridial surfaces of the tentacle have extra rows of small hooks (see Beveridge & Campbell 1996). The unique feature of the tentacular armature suggests that the erection of a new genus is justified, even though it is known only from the larval stage.

The new species was named after one of the collectors, Dr M. K. Jones, from the Centre for Microscopy and Microanalysis, University of Queensland, Australia.

Unidentified material

The following additional material, some of which represent new host records, was examined but could not be assigned to a species:

Nybelinia sp. from the spiral valve of *Rhynchobatus djiddensis*, Flat Top Island, Queensland, coll. B. G. Robertson, 25.x.1985 (SAM AHC 28325)

Nybelinia sp. from the spiral valve of *Notorhynchus cepedianus* (Péron, 1807), south coast Kangaroo Island, South Australia, coll. B. G. Robertson, 10.ii.1985 (SAM AHC 28327)

Nybelinia sp. from the stomach of *Notorhynchus cepedianus*, Young Rocks, Kangaroo Island, South Australia, coll. B. G.

Robertson, 23.v.1985 (SAM AHC 21354, 28328)

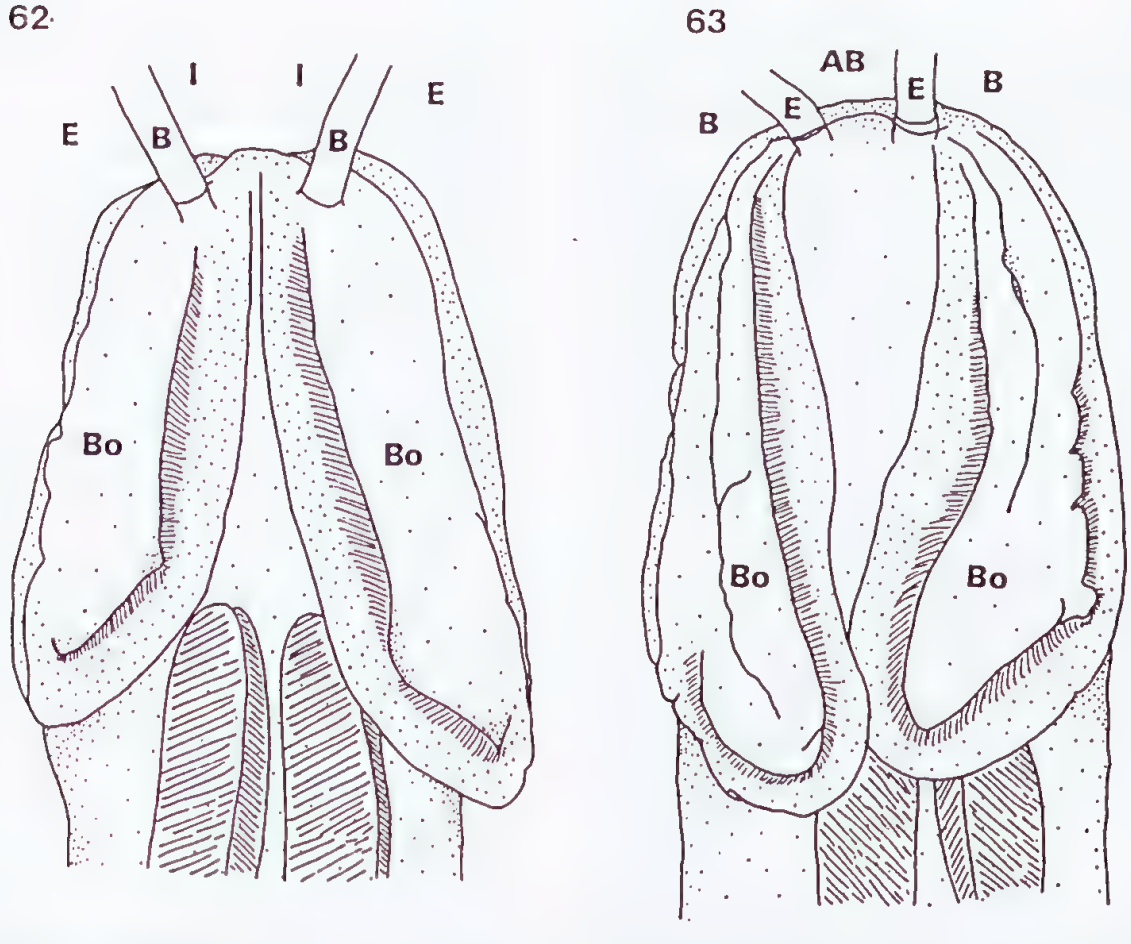
Heteronybelinia sp. from the spiral valve of *Carcharhinus amblyrhynchoides*, Tommy Cut Mouth, Northern Territory, coll. B. G. Robertson, 19.ix.1986 (SAM AHC 18326).

Discussion

The present study provides an overview for the first time of the tentacullariid trypanorhynch fauna from the Australian region. Three new species are added to the genus *Nybelinia*, two to *Heteronybelinia* and one to *Mixonybelinia*, with the latter two genera, as well as *Kotorella*, reported from the Australian region for the first time. In addition, a new genus *Kotorelliella* gen. nov., is erected, which is characterised by a homeoacanthous, heteromorphous metabasal armature and a heteroacanthous basal armature. Other features such as the elongated, widely spaced bothridia and the short bulbs appear similar to *Kotorella*.

The tentacullariid trypanorhynch fauna in Australian waters is relatively species rich with 22 (48 %) of the total of 46 known species occurring in these waters. Several of the new species may be endemic. However, the distribution of many species is still imperfectly known and a number of species previously thought to be endemic to a specific region have subsequently proven to be cosmopolitan (Palm et al. 1997; Palm 1999; Palm & Walter 1999, 2000). Reasons for broad distributions within tentacullariid trypanorhynchs may relate to life-cycle patterns, including widely distributed fish intermediate and elasmobranch definitive hosts. Another reason might be the low host specificity of the parasites, particularly in the intermediate host (Palm et al. 1997; Palm & Walter 2000).

It is difficult to clearly distinguish between



FIGURES 62–63. Schematic drawing of scolex of *Heteronybelinia pseudorobusta* sp. nov. from *Lepidotrigla modesta*, illustrating the arrangement of the different tentacle surfaces within tentacullariid trypanorhynchs. **62.** View from bothridial surface, with bothridial borders merging at the apex of the scolex. **63.** View from external surface, with bothridial borders widely spaced. Abbreviations, AB = antibothridial view, B = bothridial view, Bo = bothridia, E = external view, I = internal view.

some tentaculariid species solely on the basis of the tentacular armature (eg *N. strongyla*), and additional taxonomic characters are required. To date, the strobilae of only a few tentaculariid species have been described in detail. The present study demonstrates that, apart from the number and size of different genital structures, the cirrus sac length:width ratio might be a useful character as, for example, in *H. australis* sp. nov. and *N. hemipristis* sp. nov. The position of the anterior end of the cirrus sac and the distance of the genital pore from the anterior end of the segment, as well as the number of layers of testis, whether the testes are confluent posterior to the ovary, and the number of testes anterior to the cirrus sac appear to be useful taxonomic features. Further species descriptions are needed to show whether or not these characters are variable, as is observed in a number of scolex characters, or whether they can be used more widely in tentaculariid systematics.

During this and previous studies, it became evident that the descriptions of the different tentacular surfaces of trypanorhynch cestodes used by Dollfus (1942) and Campbell and Beveridge (1994) may be difficult to apply to larval tentaculariids. In many cases it was hard to identify the various tentacle surfaces. For a better understanding of the position of the four tentacles within tentaculariid trypanorhynchs, the following two schematic illustrations are given (Figs 62, 63) as they may help to standardise the orientation of the different tentacle surfaces within tentaculariid trypanorhynchs. The determination of tentacle orientation is based upon whether the bothridial borders merge at the apex of the scolex (Fig. 62) or whether they are widely spaced (Fig. 63). The former figure shows the bothridial and the latter the external view of the tentacle surfaces.

The description of *Kotorelliella jonesi* gen. et sp. nov. is of particular interest since its armature comprises both homeomorphous and heteromorphous components (Campbell & Beveridge 1994; Palm 1995, 1997). The species seems to be closely related to *Kotorella pronosoma*, which has a similar scolex morphology and metabasal armature. Both species have characteristic microtriches along the bothridial borders, which appear similar to those of *Tentacularia coryphaenae* and species of *Nybelinia* (see Palm & Overstreet 2000). Although Beveridge et al. (1999) could not align *Kotorella* with the other tentaculariid genera using cladistic analyses, we consider that *Kotorella pronosoma* and *Kotorelliella jonesi* belong to the Tentaculariidae since they possess a homeoacanthous metabasal armature and, more importantly, bands of hook-like microtriches along the bothridial borders. The latter character has as yet only been described for tentaculariid trypanorhynchs.

Following the classification of Dollfus (1942), only the metabasal armature is considered in classifying the tentacular armature. However, in more recent classifications, trypanorhynchs with a distinct basal armature such as *Mixodigma leptaleum* Dailey & Vogelbein, 1974, *Paroncomegas araya* (Woodland, 1934) and *Mixonybelinia beveridgei* (Palm, Walter, Schwerdtfeger & Reimer, 1997) have been placed in distinctive genera based in part on the basal armature (Campbell & Beveridge 1994; Campbell et al. 1999; Palm 1999). *Kotorelliella jonesi* has thus been placed in a new genus. Interestingly, *K. jonesi* represents a transition from homeoacanthous towards heteroacanthous armature as suggested by Campbell and Beveridge (1994, p. 57, lines 7–11).

In summary, tentaculariid trypanorhynchs show considerable morphological variability, as can be seen by differences in scolex morphology between the genera *Nybelinia*, *Heteronybelinia* and *Mixonybelinia*, and between *Kotorella* and *Kotorelliella*. The tentacular armature also differs between the species, varying from homeoacanthous and homeomorphous (*Nybelinia*, *Mixonybelinia*) to homeoacanthous and heteromorphous (*Heteronybelinia*, *Kotorella*, *Mixonybelinia*) patterns. *Kotorelliella* has a homeoacanthous metabasal and a heteroacanthous basal hook pattern. Additional methods, such as molecular genetic studies, might help to resolve not only species relationships but also the phylogenetic relationships of the species and species groups within this large trypanorhynch family.

Acknowledgments

Collecting was supported financially by the Australian Biological Resources Study and the Australian Research Council. Financial support was also provided by the German Research Council DFG PA 664/3–1 and 3–2. We wish to thank R. A. Bray, S. Butler, T. H. Cribb , M. K. Jones, R. Martin, M. O'Callaghan, R. Norman, J. C. Pearson, S. Pichelin, J. Reddich, B. G. Robertson , K. Sewell, P. Speare and J. Stevens for their contributions to this study.

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TWO NEW SPECIES OF THE GENUS *LEPANUS* BALTHASAR FROM SOUTH AUSTRALIA (COLEOPTERA: SCARABAEIDAE)

E. G. MATTHEWS & T. A. WEIR

MATTHEWS, E. G. & WEIR, T. A. 2002. Two new species of the genus *Lepanus* Balthasar from South Australia (Coleoptera: Scarabaeidae). *Records of the South Australian Museum.* 35(1): 79–84.

Ball-rolling dung beetles of the tribe Scarabaeini are recorded for the first time from South Australia. The new species *Lepanus penelopae* and *L. loftyensis* are described from southern Eyre Peninsula and the Mount Lofty Block respectively, and are compared with other species of the genus. There are brief remarks comparing *Lepanus* Balthasar with the related genera *Sauvagesinella* Paulian and *Aptenocanthon* Matthews.

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At the time of the revision by Matthews (1974) of the Australian Scarabaeini, generally known as ball-rolling dung beetles, it was believed that this group was absent from South Australia, although it was known from Victoria and Western Australia. However, in 1979 P. Greenslade obtained specimens of an undescribed species of the genus *Lepanus* Balthasar, which belongs to this tribe, in the Marble Range of southern Eyre Peninsula; and in 1982 another undescribed species of the same genus was collected during extensive pitfall trapping undertaken by J. and P. Greenslade in Kuitpo Kyeema Forest, southern Mount Lofty Ranges, in connection with a project to determine the effects of fire on the forest-floor fauna. Then in 1999 and 2000, more specimens of the second species were picked up by members of the Biological Survey of South Australia in the area of Mount Remarkable at the extreme northern end of the Mount Lofty Block environmental province, as well as near the Barossa Valley, using unbaited pitfall traps. Altogether, the two species are now known from five collection localities (Fig. 1), all situated on low mountain ranges at altitudes from 300 to just over 500 m. Kangaroo Island is part of the Mount Lofty Block but pitfall traps baited with human faeces, set throughout the island by one of the authors (EGM) in November 1990, failed to collect any *Lepanus*.

Lepanus is known from New Guinea, where it was first described, and from densely vegetated mesic and humid habitats along the northern, eastern and southern coasts of Australia as far west as the tingle forest near Walpole, Western Australia (Matthews 1974). The habitat is leaf litter, and food, where known, consists of vertebrate faecal matter. The descriptions below bring the total number of described Australian species of *Lepanus* to 23, but several undescribed species have been collected in recent years in eastern montane forests (R. Storey, pers. comm.).

Specimens are deposited in the South Australian Museum, Adelaide (SAMA); the Australian National Insect Collection, Canberra (ANIC); the Queensland Museum (QMBA); and the Queensland Department of Primary Industries collection at Mareeba (DPIM).

All figures except the map are by the senior author.

Descriptions Of New Species

Lepanus penelopae sp. nov.
(Figs 1, 2, 3, 5, 7, 9, 12)

Holotype

'S. Aust. Eyre Pen. Marble Rge. Dense broombush. Pitfall. 4.10.79. P.J.M. Greenslade', male, SAMA.

Paratypes

Same data as holotype, 1 male and 5 females, ANIC, SAMA.

Description

Body uniformly piceous and nitid, legs rufous. Total length 5.0–6.0 mm. Maximum width across

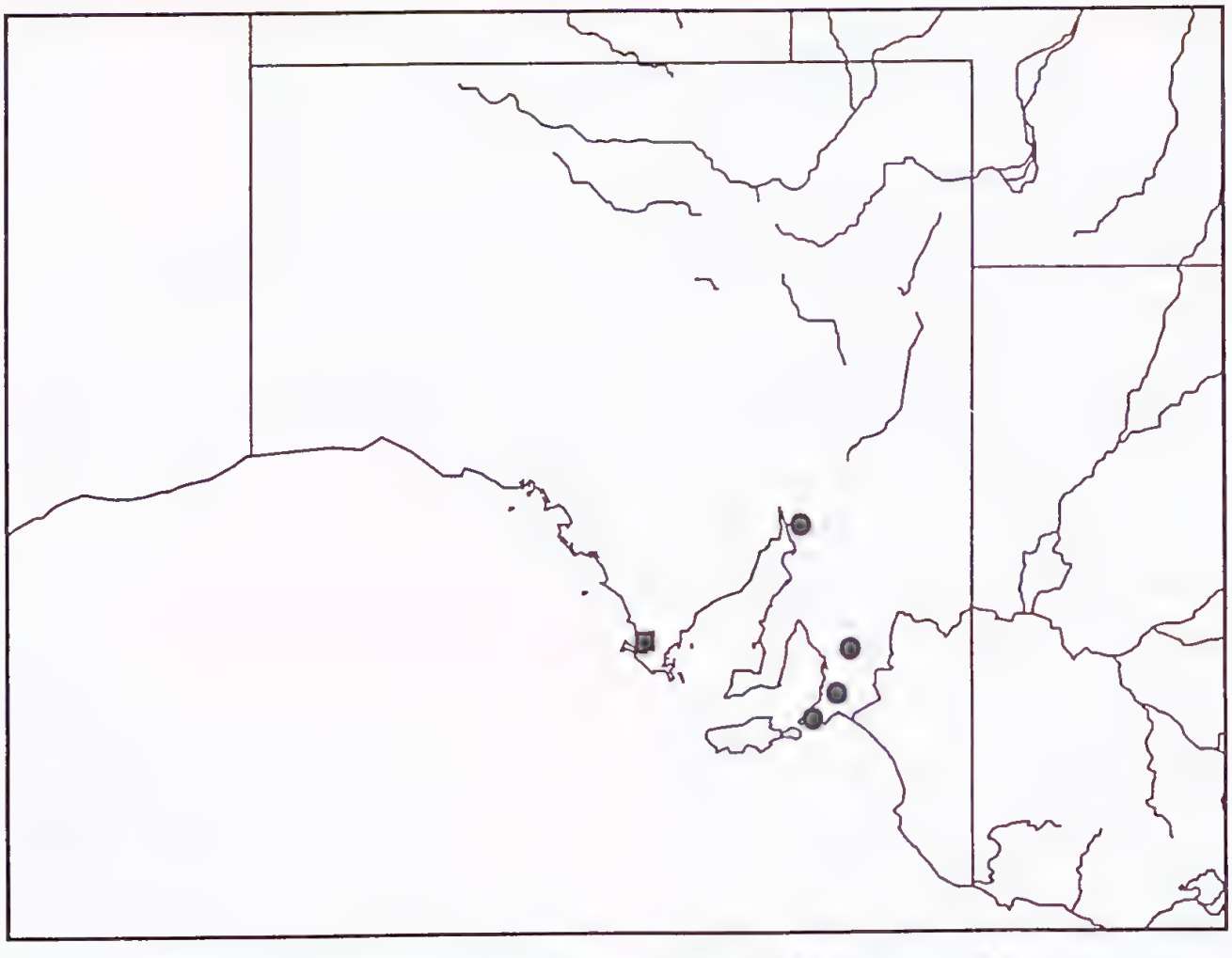


FIGURE 1. Known distribution in South Australia of species of *Lepanus*. ■, *L. penelopae*; ●, *L. loftyensis*.

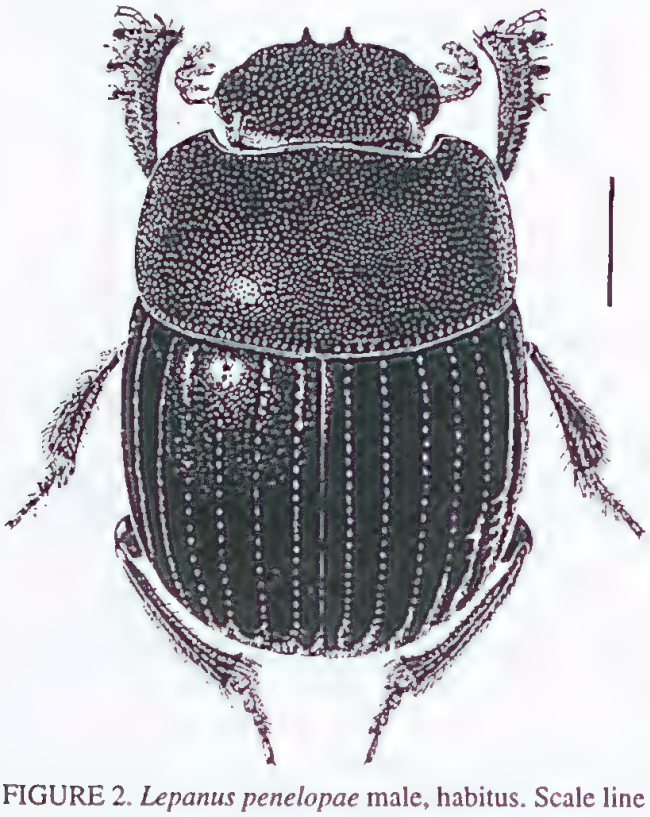
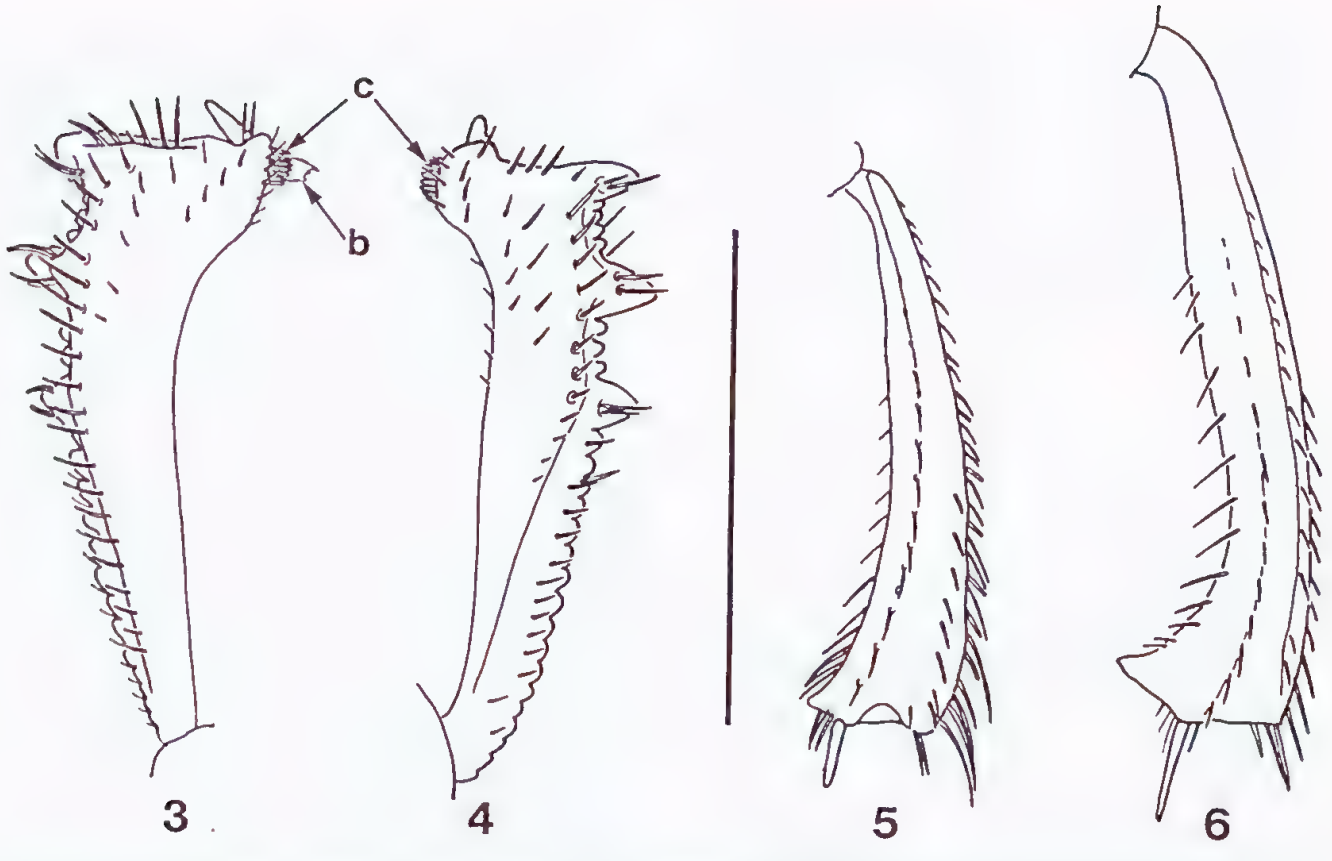


FIGURE 2. *Lepanus penelopae* male, habitus. Scale line 1 mm.

elytra 3.4–3.6 mm. *Head* – Dorsal surface even, very densely punctate with small shallow punctures not running together, some bearing short, very fine recumbent setae. Dorsal part of eye small, its maximum width contained about 25 times in interocular distance. *Prothorax* – Anterior angles subquadrate. Sides of pronotum rounded, widest at broadly rounded posterior angles. Dorsal surface very densely and uniformly finely punctate, punctures separated by distances equal to a little more than their diameter, glabrous. *Elytra* – Striae shallowly impressed with regularly spaced moderately deep punctures separated by 2–4 diameters. Intervals nearly flat, smooth with very slightly uneven surface, glabrous, with minute punctures. *Hind wings* – Absent. *Sterna* – Meso- and metasterna impunctate medially with large shallow cicatricose punctures laterally, glabrous. *Legs* – Protibia with three large teeth on outer edge, which is serrate between teeth and proximal to them. Claws (Fig. 7) a little expanded basally but not distinctly angulate or dentate. *Abdomen* – Pygidium (Fig. 9) with a very deep



FIGURES 3–6. Tibiae of males in dorsal view. **3**, *L. penelopae*, left protibia; **4**, *L. loftyensis*, right protibia; **5**, *L. penelopae*, right metatibia; **6**, *L. loftyensis*, right metatibia. **b**, brush of stiff setae; **c**, comb of flattened bristles. Scale line 1 mm.

basal groove across whole width of disc, groove narrower and shallower in middle, surface inside it transversely striated. Disc very finely punctate, glabrous. Aedeagus as in Fig. 12. *Sexual dimorphism* – Male with rounded expansion of inner apical end of protibia bearing apical comb of short wide flattened bristles (Fig. 3, c) and on lower surface a brush of long setae which is directed outwardly parallel to surface, extending beyond edge of comb (Fig. 3, b). Metatibia of male (Fig. 5) a little expanded at inner apical edge and bearing small apical tooth there.

Remarks

In the key to the species of *Lepanus* published by Matthews (1974), *L. penelopae* will go to couplet 16 because it has three protibial teeth, and then to couplet 18 because it has a transverse groove on the pygidium and glabrous dorsal surfaces. However, it does not have dentate claws as also required by this couplet. It can then be forced through couplets 19 and 20 to end up with *L. illawarrensis* Matthews of New South Wales, which appears to be the most closely related species, sharing many aspects of structure and secondary sexual characters. *L. penelopae* differs from *L. illawarrensis* in having simple claws, non-geminate elytral striae with much deeper strial punctures, the pygidial groove more strongly narrowed in the middle, the basal ridge of the pygidium straight in the middle, no trace of a median tubercle on the metasternum of the male, male hind tibia not twisted, and somewhat differently shaped aedeagal parameres.

Etymology

This species is named after Penelope Greenslade, who collected it as well as many of the other specimens of *Lepanus* described in this paper.

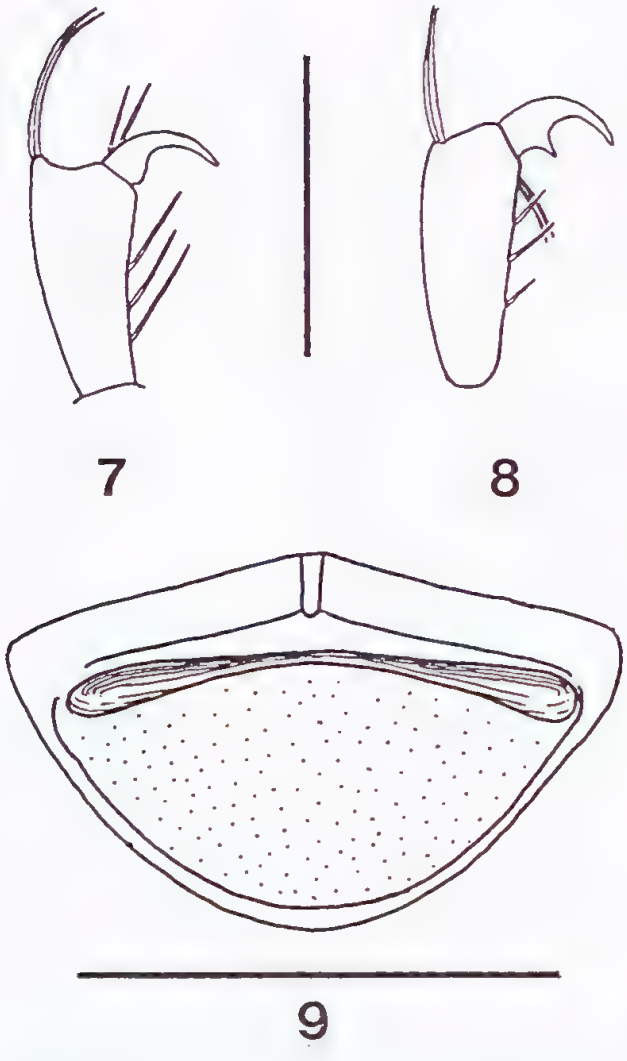
Lepanus loftyensis sp. nov.
(Figs 1, 4, 6, 8, 10, 11)

Holotype

'S. AUST. Pitfalls Kuitpo Kyeema Forest 15th March, 1982 P. Greenslade', male, SAMA.

Paratypes

Same data as holotype, 12 males, 4 females, ANIC, SAMA. 'S. Aust. Deep Ck Boat Hbr Lane



FIGURES 7–9. 7, *L. penelopae*, claw segment of metatarsus; 8, ditto, *L. loftyensis*. Scale line 0.25 mm; 9, *L. penelopae*, pygidium of male. Scale line 1 mm.

turnoff pitfalls in heath 1–8 Dec 1983 P. Greenslade', 1 female, SAMA. 'S. AUST. Mt Remarkable NP 11 km SSW Wilmington 32° 44'56"S 138°04'03"E 20–25 Nov 99 pitfall Flinders Ra. MAM00401', 5 females, ANIC, SAMA. 'S. AUS. 11 km SE Whispering Wall (near Para Wirra) 34°34'54"S 138°55'12"E 27-10-00 SMLR Survey BAR 03201', 17 males, 31 females, SAMA, QMBA, DPIM.

Description

Body uniformly fuscous to piceous, legs rufous. Total length 3.4–5.5 mm, maximum width across elytra 2.3–3.6 mm. *Head* – Surface even, very densely punctate with shallow coarse punctures running together in irregular transverse rows, bearing small recumbent setae. Dorsal part of eye small, slit-like, its maximum width contained about 30 times in interocular distance. *Prothorax* – Anterior angles obtuse. Sides of pronotum widest about one-quarter of the distance behind anterior angles, thereafter slightly converging or subparallel to broadly rounded posterior angles. Dorsal surface very densely and uniformly punctate, punctures separated by distances equal to less than their diameter, bearing very fine, short, fully recumbent setae. *Elytra* – Striae very superficial, geminate with slightly crenulate edges, impunctate. Discal intervals flat, in same plane as striae, with more or less undulate surface, finely shagreened, with a row of punctures bearing recumbent setae along edges of each interval, an additional row usually present in middle of intervals near base. *Hind wings* – Atrophied, represented by short stubs. *Sterna* – Mesosternum with shallow punctures on posterior half. Metasternum entirely densely punctate with shallow punctures laterally bearing short, fine recumbent setae. *Legs* – Protibia (Fig. 4) with 3 large teeth on outer edge, which is serrate between teeth and proximal to them. Claws (Fig. 8) strongly dentate. *Abdomen* – Pygidial disc simple, without groove, uniformly densely and shallowly

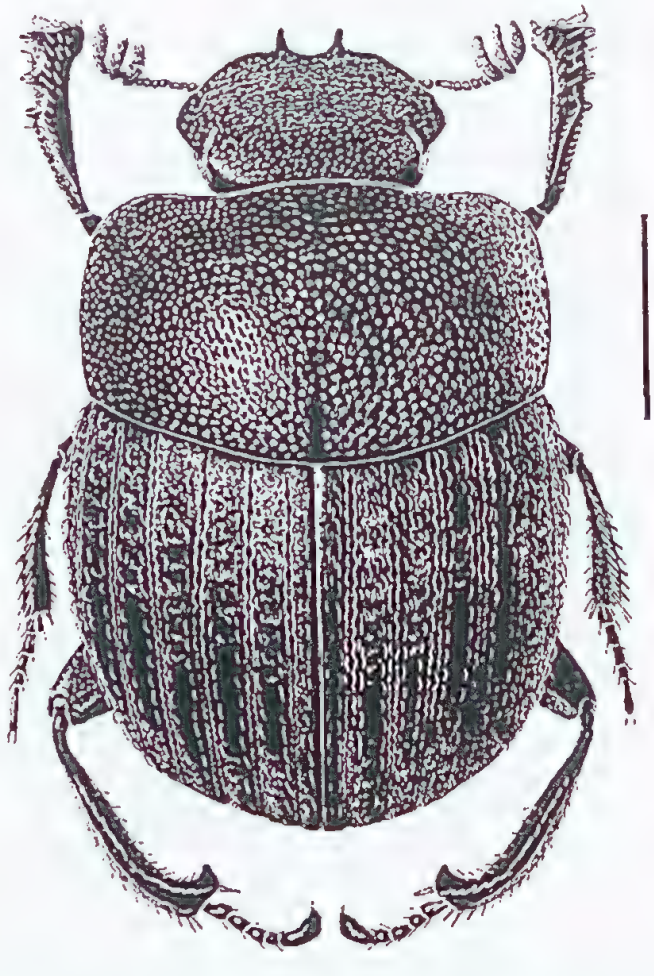


FIGURE 10. *Lepanus loftyensis* male, habitus. Scale line 1 mm.

punctate, punctures bearing very small recumbent setae usually worn off. Aedeagus as in Fig. 11. *Sexual dimorphism* – Male with rounded expansion of inner apical end of protibia bearing apical comb of short, wide, flattened bristles (Fig. 4, c) and a brush of long setae underneath which is directed downward perpendicular to surface. Metatibia of male (Fig. 6) with strongly recurved apical end bearing acute inner tooth. Prothorax of male broader anteriorly, subquadrate; that of female slightly narrower anteriorly. Clypeal teeth of male slightly smaller than those of female.

Remarks

In the key to species of *Lepanus* in Matthews (1974) *L. loftyensis* will first go to couplet 16 because it has three teeth on the outer edge of the protibia, then to couplet 17 because it has a simple pygidium and setose dorsal surfaces, then to *L. villosus* Matthews of north Queensland because of its crenulate elytral striae and densely punctate meso- and metasterna. It differs from *L. villosus* in having superficial elytra striae, reduced hind wings, very different parameres of the aedeagus, and being of much larger size. Further, *L. loftyensis* has the setae on the pronotum only about half the length of those on the elytra, the first elytral interval with a double row of seta-bearing punctures, and the upper edges of the epipleural carina not visible from directly above due to the curvature of the elytra.

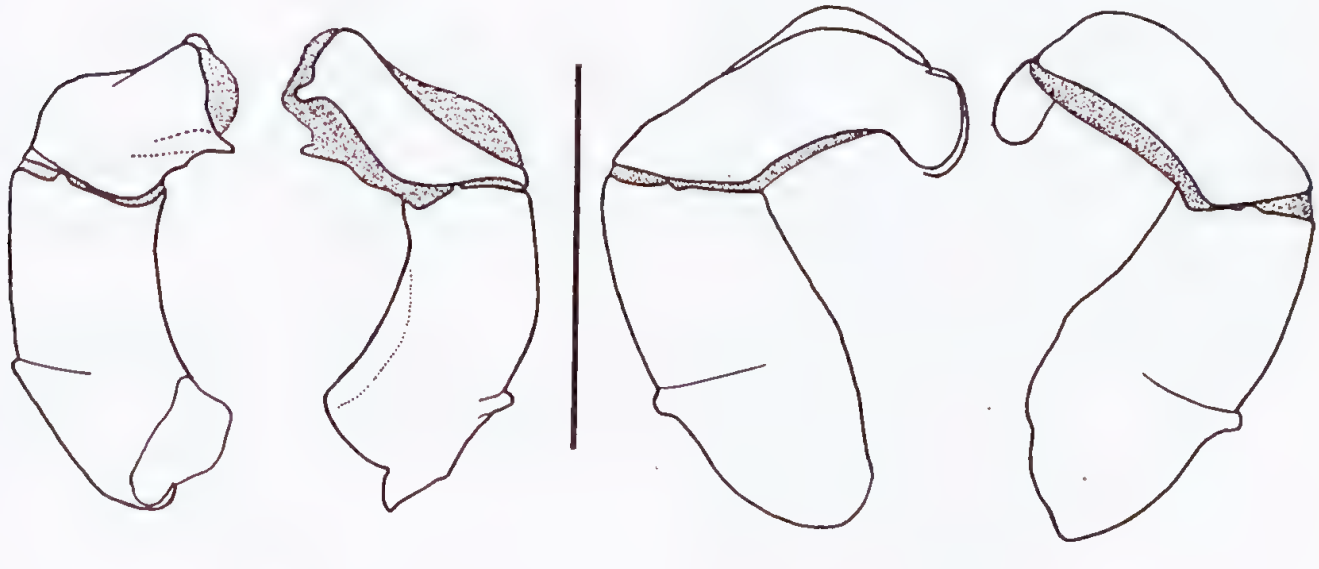
The designation MAM 00401 on labels of the Mount Remarkable specimens refers to a locality which is described in Brandle (2001) as mountainous, on a hill crest, with loam/sand soil and an overstorey of *Allocasuarina verticillata* at a cover density of 25–50%, and at an altitude above sea level of 430 m. For the Parra Wirra specimens the designation BAR 03201 refers to a ridge top covered with *Eucalyptus fasciculosa* / *Acacia paradoxa* woodland and an understorey of *Calytrix*, *Hakea* and *Xanthorrhoea*, at an altitude of 515 m (L. Queale, pers. comm.).

Etymology

The name refers to the Mount Lofty Block environmental province in which all four collection localities of this species are contained. The block is Province number 3 as delineated in the Biological Survey of South Australia, and extends from Kangaroo Island northward to Mount Remarkable. The biota of this province is characterised as fully Bassian (Brandle 2001).

Discussion

The existence of the species here described as *Lepanus loftyensis* was briefly noted by Matthews (1984: 6, footnote) erroneously as an undescribed species of *Sauvagesinella* Paulian. *Lepanus* and *Sauvagesinella* are closely related genera which are not separable in the female sex, but in the male there are several secondary sexual characters which will distinguish them. Unlike *Lepanus*, *Sauvagesinella* males have a prominent median



FIGURES 11 & 12. Aedeagi in right and left views. **11**, *L. loftyensis*; **12**, *L. penelopae*. Scale line 1 mm.

tubercle on the metasternum (only a trace of a tubercle in some *Lepanus*), a row of close-set tubercles along the inner edge of the metatibia, and a more or less compressed metafemur with a longitudinal fold or ridge on its ventral surface. *Sauvagesinella* as understood here does not occur outside the extreme southern part of Western Australia, where there are three species (Matthews 1974).

Storey and Monteith (2000) mention that males of all species of *Aptenocanthon* Matthews, where known, have a similar form of the fore tibial apex with its inner angle expanded and bearing a short brush of stiff setae bent downwards at right angles to the upper tibial surface. This is a similar situation to that found in the two species of *Lepanus* described above (eg Fig. 3, b) and is also known to occur in several other species of *Lepanus* and all three species of *Sauvagesinella*. As well as this brush, there is a comb of flattened bristles at the protibial apex (Figs 3 and 4, c) which occurs, to varying degrees, in all known males of *Aptenocanthon* and *Sauvagesinella* as well as some species of *Lepanus*. Clearly, these male characters are not limited to *Aptenocanthon* but their value in classification must await further studies on the interrelationships of these genera of Scarabaeini, as also pointed out by Storey and Monteith (2000).

In South Australia the only other known representatives of the dung beetle subfamily Scarabaeinae belong to the tribes Onthophagini (native and introduced *Onthophagus* Latreille), Onitini (introduced *Onitis* Fabricius) and Oniticellini (introduced *Euoniticellus* Janssens), none of which make or roll food balls. All these groups are differentiated from the tribe Scarabaeini by their middle and hind tibiae, which are strongly expanded apically. In Scarabaeini these tibiae are slender and only a little expanded, an adaptation for rolling the food material.

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A CHECKLIST OF *CISSEIS* (*SENSU STRICTO*) GORY & LAPORTE, 1839 (COLEOPTERA: BUPRESTIDAE: AGRILINAE).

SHELLEY BARKER

BARKER, S. 2002. A checklist of *Cisseis* (*sensu stricto*) Gory & Laporte, 1839 (Coleoptera: Buprestidae: Agrilinae). *Records of the South Australian Museum* 35(1): 85–90.

A checklist of *Cisseis* (*s.s.*) Gory & Laporte, 1839 is presented and discussed, summarising the information available on the genus at the present time.

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Material

Specimens examined came from the following institutions:

AMSA – Australian Museum, Sydney

ANIC – Australian National Insect Collection, CSIRO, Canberra

BMNH – The Natural History Museum, London

BPBM – B. P. Bishop Museum, Honolulu

HMOE – Hope Museum, Oxford

HUMB – Humboldt University Museum, Berlin

MCSNG – Museo Civico di Storia Naturale Genoa, Italy

MNHN – Museum National d' Histoire Naturelle, Paris

NMVA – National Museum of Victoria, Melbourne

PMCE – National Museum of Czech Republic, Prague

QMBA – Queensland Museum, Brisbane

RMBB – Royal Museum, Brussels

SAMA – South Australian Museum, Adelaide.

Abbreviations:

WA – Western Australia

NWA – Kimberly area, Western Australia

Q – Queensland

NSW – New South Wales

V – Victoria

SA – South Australia

T – Tasmania

NT – Northern Territory.

Introduction

Many of the Australian buprestid genera have not been reviewed since the death of H. J. Carter in 1941. Because of the large amount of subsequent collecting and confusion with species identification, the genera are in a parlous state of order. One of worst has been *Cisseis* (Coleoptera: Buprestidae: Agrilinae), last researched by Carter (1923, 1929). With the intention of revising *Cisseis*, the author commenced work on the group in 1997. All of the readily available types, more than half of which are housed in European museums, have now been examined. Some of the difficulties have been resolved and a number of new species described (Barker 1998, 1999a, 1999b, 2001). Some species clearly did not belong in *Cisseis* and these, together with nine new species, were placed in a new genus *Stanwatkinsius* Barker & Bellamy (2001). Carter (1923) did not examine male genitalia, which the author has found to be highly diagnostic. As a result, many of his specimens located in various museum collections are incorrectly identified. In order to summarise the knowledge available on the genus, a checklist has been constructed of valid species together with their distributions by state or country. Types and their locations are also listed. The following abbreviations are used: HT = holotype; ST = syntype; LT = lectotype; AT = allotype.

Checklist of *Cisseis* (*sensu stricto*) Gory & Laporte, 1839.

aberrans Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125:** 98. (♂ HT, Woodridge, WA, H. Demarz, SAMA I 21504). WA.

acuducta (Kirby, 1836)(*Trachys*). *Faun. Bor. Amer.*: 162. (♂ HT, N. Scotia, BMNH). Q, NSW, V, SA, T.

marmorea (Gory & Laporte, 1839)(*Ethon*). *Mon. Bupr.* **ii**: 4. (HT, MNHN not seen)

cuprifrons Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 157. (♂ HT, Australia, Standing, BMNH)

laeta Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 227. (♂ HT, Australia, Moffarts, BMNH)

adusta Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 101. (♂ HT, Lucindale, SA, Feueheerdt, SAMA I 21505). SA.

albertisi Gestro, 1877. *Ann. Mus. Civ. Stor. Nat. Genova.* **9**: 357. (3 ST sex unknown, Somerset, Australia, D'Albertis, 1/75 MCSNG; ♀ ST, Somerset, Australia, RMBB). Q.

albosparsa Gory & Laporte, 1839. *Monograph* **ii**: 3. (HT, MNHN not seen). NT, Q.

cupriventris Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 161. (♀ HT, Australia, Chevrolat, BMNH).

inflammata Carter, 1923. *Proc. Linn. Soc. N.S.W.* **48**: 167. (♂ HT, S. Johnstone R., Q, H. W. Brown AMSA K67240) (new syn.).

aquilonia Bellamy, 1991. *Tijdschr. v. Ent.* **134**: 171. (♂ HT, BPBM not seen). Philippine Arch.

armstrongi Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 101. (♂ HT, Bogan R., NSW, J. Armstrong, NMVA). NSW.

augustgoerlingi Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 102. (♂ HT, Marloo Stn., Wurarga, WA, A. Goerling, ANIC). WA.

aurocyanea Carter, 1934. *Proc. Linn. Soc. N.S.W.* **59**: 258. (♀ HT, Fletcher, Q, E. Sutton, AMSA K67296). NSW, Q.

bedfordi Obenberger, 1923. *Casopis Cs. Spol. Entom.* **32**: 9. (♀ HT, Cape Bedford, Q, NMPC). Q.

brooksi Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 102. (♂ HT, Mareeba, Q, J. G. Brooks, ANIC). Q.

broomensis Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 103. (♂ HT, Broome, WA, H. W. Brown, SAMA I 21509). NWA.

browni Carter, 1934. *Proc. Linn. Soc. N.S.W.* **59**. 258. (♂ HT, Dedari, WA, H. W. Brown, AMSA K67297). WA.

carterella Obenberger, 1935. *Col. Catalogus* **12**: 846. (♀ LT, Herberton, Q, C. J. Wild, QMBA)(replac. name). Q.

elliptica var. *frontalis* Carter, 1923. *Proc. Linn. Soc. N.S.W.* **48**: 170. (homonym).

carteri Obenberger, 1924. *Archiv. für Naturg.* **90**: 109. (♂ LT, Yilgarn, WA, NMPC). WA.

chalcophora Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 103. (♂ HT, Kapunda, SA, S. Barker, SAMA I 21507). SA.

clermonti Théry, 1945. *Bull. Soc. Ent. Fr.* **50**: 46. (HT, MNHN not seen). Bougainville.

corpulenta Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 104. (♂ HT, Tallering stn., Pindar, WA, S. Barker, SAMA I 21511). WA.

cupreicollis (Hope, 1846)(*Ethon*). *Ann. Mag. Nat. Hist.* **17**: 64. (♂ HT, Moriatta (*sic*), SA, HMOE no. 893). SA

aenicollis (Hope, 1846)(*Ethon*). *Ann. Mag. Nat. Hist.* **17**: 65. (♀ HT, Adelaide, HMOE no. 892 2/2).

cupreola Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 105. (♂ HT, Mt Spec, Q, J. G. B., ANIC). SA, NSW, Q.

cupripennis (Guerin, 1836)(*Buprestis*). *Voy. Coquille*: 65. (HT, MNHN not seen). NSW, V.

semiscabrosa Thomson, 1879. *Typi Bupr. Mus. Thomson. App.* **1A**: 53. (♂ HT, Sydney)(new syn.).

nitidicollis Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 162. (♂ HT, Australie, Bates, BMNH)(new syn.).

cyanea Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 105. (♂ HT, Wialki, WA, S. Barker, SAMA I 21512). WA.

cyaneopyga Carter, 1923. *Proc. Linn. Soc. N.S.W.* **48**: 170. (♀ LT, Lake Austin, WA, H. W. Brown, AMSA K67292). WA.

goerlingi Carter, 1936. *Proc. Linn. Soc. N.S.W.* **61**: 104. (♀ HT, Marloo stn., Wurarga, WA, A. Goerling, AMSA K67466)(new syn.).

cyanura Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 163. (2 ♂♂ ST & ♀ ST, BMNH). Q.

derbyensis Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 106. (♂ HT, Derby, H. W. Brown, SAMA I 21520). NWA.

duodecimmaculata (Fabricius, 1801)(*Buprestis*). *Sys. Eleuth.*: 191. (HT sex unknown, BMNH). All mainland states.

duodecimguttata (Boisduval, 1835) (*Buprestis*). *Voy. Astrolabe, Entom.* **2**: 93. (HT, MNHN not seen).

quaturodecimnotata Hope, 1846. *Ann. Mag. Nat. Hist.* **17**: 64. (HT not seen, HMOE).

pustulata Thomson, 1879. *Typi Bupr. Mus.*

Thoms. App **1A**: 51. (HT sex unknown, MNHN).

biologia Froggatt, 1910. *Australian Insects*: 165. (HT not seen, AMSA?)(new syn.).

fallaciosula Obenberger, 1935. *Acta. Soc. Ent. Csl.* **32**: 36. (HT sex unknown, PMCE)(new syn.).

elongatula Blackburn, 1888. *Proc. Linn. Soc. N.S.W.* **3**: 892. (♂ HT, NT, SAMA). NT.

elliptica Carter, 1923. *Proc. Linn. Soc. N.S.W.* **48**: 170. (♀ LT, Cue, WA, H. W. Brown, NMVA). WA.

excelsior Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 107. (♂ HT, Mt Carbine, Q, T. M. S. Hanlon & M. Powell, SAMA I 21514). Q.

ernestadamsi Barker, 1999. *Rec. S. Aust. Mus.* **32**: 46. (♂ HT, Edungalba, Q, E. E. Adams, ANIC). Q.

fascigera Obenberger, 1919. *Ent. Mitteilungen* **8**: 20. (♂ HT, New Guinea, PMCE no. 23772). New Guinea.

fraterna Kerremans, 1900. *Mem. Soc. Ent. Belg.* **7**: 80. (♀ HT, Germ. N. G., Webster, BMNH). New Guinea.

frontalis Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 157. (♂ HT, New Guinée, Standing, BMNH). New Guinea.

fulgidicollis Macleay, 1888. *Proc. Linn. Soc. N.S.W.* **3**: 1231. (2 ♂♂ ST, Derby, NWA, ANIC). NWA, Q.

gibbera (Carter, 1937)(*Neospades*). *Trans. Roy. Soc. S. Aust.* **61**: 121. (♀ HT, Mullaly, NSW, H. J. Carter, AMSA K111950). NSW.

gouldi (Hope, 1846)(*Ethon*). *Ann. Mag. Nat. Hist.* **17**: 65. (♀ HT, Port Essington, HMOE no. 889). NT.

heroni Carter, 1934. *Proc. Linn. Soc. N.S.W.* **59**: 259. (♂ HT, Dorrigo, NSW, W. Herron, AMSA K67298). NSW.

impressicollis Macleay, 1878. *Ent. Soc. N.S.W.* **2**: 248. (♀ HT, Gayndah, AMSA K32713). Q.

viridiaurea Macleay, 1878. *Ent. Soc. N.S.W.* **2**: 248. (2 ♀♀ ST, Gayndah, AMSA no. K32712)(new syn.).

viridicuprea Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 160. (♀ HT, Cocktown (*sic*), Standing, BMNH)(new syn.).

nitida Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 164. (♂ HT, Cocktown (*sic*), BMNH)(new syn.).

inops Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 168. (♀ HT, Australie, Standing, BMNH). NSW.

kohouti Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 107. (♂ HT, Canberra, K. Pullen, ANIC). NSW, Q.

laticollis Carter, 1923. *Proc. Linn. Soc. N.S.W.* **48**: 169. (♀ HT, BMNH). Q.

leucosticta (Kirby, 1818)(*Buprestis*). *Trans. Ent. Soc. Lond.* **12**: 382. (♀ HT, BMNH). All mainland states.

aurulenta Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 159. (♀ HT, Australia, Chevrolat, BMNH)(new syn.).

fulgidifrons Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 161. (♀ HT, Australia, Chevrolat, BMNH).

macmillani Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 108. (♂ HT, Wanneroo, WA, R. P. McMillan, SAMA I 21516). WA.

macqueeni Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 108. (♂ HT, Milmerran, Q, J. Macqueen, ANIC). Q.

maculata (Gory & Laporte, 1839)(*Ethon*). *Mon. Bupr.* **ii**: 5. (HT, MNHN not seen). NSW.

marmorata Gory & Laporte, 1839. *Mon. Bupr.* **ii**: 4. (HT, MNHN not seen). NSW, Q.

viridicollis Thomson, 1879. *Typi Bupr. Mus. Thomson. App.* **1A**: 50. (♂ HT, MNHN).

aena Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 158. (3 ♀♀ ST, Sydney, Bates, BMNH).

minutissima Thomson, 1879. *Typi Bupr. Mus. Thomson. App.* **1A**: 54. (HT, MNHN not seen). SA, V.

simplex Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 171. (2 ♂♂ ST & ♀ ST, Australie, Standing, BMNH)(new syn.).

modesta Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 170. (♂ HT, Australie, Stark, Chevrolat collection, BMNH). WA, SA, V.

myallae Carter, 1934. *Proc. Linn. Soc. N.S.W.* **59**: 260. (♀ HT, Bogan R., NSW, J. Armstrong, AMSA K67299). NSW.

nigrita Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 168. (♂ HT, Australie, Fairmaire, BMNH).

nigripennis Macleay, 1888. *Proc. Linn. Soc. N.S.W.* **3**: 1231. (♂ HT, Barrior (*sic*) Range, NWA, Froggett, ANIC). NT, WA.

ignicollis Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 164. (♂ ST, Australie, Standing, BMNH; ♂ ST, Australie, Chevrolat, BMNH; 2 ♂♂ ST, Port Denison BMNH)(new syn.).

nigromaculata Kerremans, 1895. *Ann. Soc. Ent. Belg.* **39**: 218. (HT not in BMNH). Malacca.

nitidiventris Carter, 1934. *Proc. Linn. Soc. N.S.W.* **59**: 260. (♀ HT, Gosford, NSW, N. MacGregor, AMSA K67300). NSW, Q.

niveosparsa (Carter, 1927)(*Neospades*). *Proc. Linn. Soc. N.S.W.* **52**: 228. (♂ HT, Bogan R., NSW, J. Armstrong, AMSA K67288). NSW, SA.

notulata (Germar, 1848)(*Ethon*). *Linn. Ent.*: 178. (♂ HT, Adelaide, HUMB). SA, NSW, T.

atroviolacea Thomson, 1879. *Typi. Bupr. Mus. Thoms. App.* **1A**: 52. (♂ ST & ♀ ST, Austr, MNHN)(new syn.).

morosa Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 158. (2 ♂♂ ST, Australie, Stark, BMNH)(new syn.).

nubeculosa (Germar, 1848)(*Ethon*). *Linn. Ent.*: 176. (♀ LT, Adelaide, HUMB). SA, V.

chalcoptera (Germar, 1848)(*Ethon*). *Linn. Ent.*: 177. (2 ♂♂ ST, Adelaide, HUMB).

similis Saunders, 1871. *Cat. Bupr.*: 103. (♀ HT, Adelaide, BMNH)(new syn.).

oblonga Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 229. (♀ HT, Australie, Fairm., BMNH). V, NSW, Q, T.

obscura Blackburn, 1887. *Trans. R. Soc. S. Aust.* **10**: 252. (♀ HT, T 320, type locality unknown, BMNH)(unique).

opima Thomson, 1879. *Typi Bupr. Mus. Thomson. App.* **1A**: 50. (♀ HT, Champion Bay, MNHN). WA.

ovalis Carter, 1923. *Proc, Linn. Soc. N.S.W.* **48**: 170. (♀ HT, Nov. Holl. occid., Fry Coll. 1905.100, BMNH 37811)(unique). WA.

parva Blackburn, 1887. *Trans. R. Soc. S. Aust.* **10**: 253. (♂ HT, BMNH). WA, SA, V, NSW.

pygmaea Blackburn, 1891. *Trans. R. Soc. S. Aust.* **14**: 299. (♀ HT, Victoria, C. French, NMVA)(new syn.).

patricia Carter, 1935. *Proc. Linn. Soc. N.S.W.* **55**: 180. (♂ HT, Bunbury, WA, F. L. Whitlock, AMSA K67302). WA, V, NSW.

pauperula Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 167. (♂ HT, Australie, A. Deyr., Chevrolat collection, BMNH). T.

prasina Carter, 1923. *Proc. Linn. Soc. N.S.W.* **48**: 168. (♂ LT, Australia, Blackburn's collection, 3267, SAMA). SA, Q.

puella Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 170. (2 ♂♂ ST & ♀ ST, Australie, Fairm., BMNH). Q.

curta Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 229. (♂ HT, Peak Downs, Fairmaire, Mus. Godeffroy no. 11142, BMNH).

pulchella Carter, 1923. *Proc. Linn Soc. N.S.W.* **48**: 171. (HT sex unknown, French collection, NMVA). Q.

pulleni Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 109. (♂ HT, Edungalba, Q, S. Barker, SAMA I 21518). ACT, Q.

regalis Thomson, 1879. *Typi Bupr. Mus. Thomson. App.* **1A**: 50. (♂ HT, Queensland, MNHN). NT, Q.

robertfisheri Barker, 1999. *Rec. S. Aust. Mus.* **32**: 47. (♂ HT, Melrose, SA, R. H. Fisher, SAMA I 21407). SA.

roseocuprea (Hope, 1846)(*Ethon*). *Ann. Mag. Nat. Hist.* **17**: 64. (♀ HT, Moriatta (*sic*), SA, HMOE no. 889). WA, SA, V, NSW.

dispar Blackburn, 1891. *Trans. R. Soc. S. Aust.* **14**: 297. (♀ HT, 3832, BMNH).

fairmairei Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 169. (♀ HT, Australie, Fairmaire, BMNH).

cuprea Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 228. (♀ HT, NSW, Standing, BMNH).

rubicunda Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 169. (♂ HT, Australie, Fairm., BMNH). WA, SA, V, NSW, Q.

undulata Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 227. (♀ HT, NSW, Standing, BMNH)(new syn.).

purpurea Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 228. (♀ HT, Sidney (*sic*), Fairm, Mus. Godeffroy no. 11108)(new syn.).

scabiosa (Boisduval, 1835)(*Buprestis*). *Voy. Astrolobe Entom.* **2**: 96. (HT, MNHN not seen).

scabrosula Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 167. (3 ♂♂ ST & ♀ ST, Australie, Fairm., BMNH). NSW, Q.

semiobscura Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 170. (♂ ST, Australie, Fairm., BMNH; 2 ♀♀ ST, Australie, Deyr., BMNH). SA, V.

septuosa Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 109. (♂ HT, Charity Ck Bridge, Manning R., NSW, S. Watkins, SAMA I 21521). SA, NSW, Q.

sexnotata Fauvel, 1891. *Rev. d'Ent.* **10**: 181. (HT, MNHN not seen). New Caledonia.

signaticollis (Hope, 1846)(*Ethon*). *Ann. Mag. Nat. Hist.* **17**: 64. (♂ HT, Port Essington, HMOE no. 891). WA, NT, Q.

speciosa Barker, 2001. *Trans. Roy. Soc. S. Aust.*

125: 110. (♂ HT, Midland Jctn, WA, R. P. McMillan, SAMA I 21523). WA.

stellata Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 111. (♂ HT, Cairns, SAMA I 21524). Q.

stigmata Gory & Laporte, 1839. *Mon. Bupr.* **ii**: 3. (HT, MNHN not seen). WA.

subbifascialis Carter, 1927. *Proc. Linn. Soc. N.S.W.* **52**: 229. (♀ HT, Bogan R., NSW. J. A., AMSA K67291). NSW.

tasmanica Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 165. (♀ ST, Tasmanie, Oberthur, BMNH; ST, Tasmanie, Chevrolat, BMNH). T, V, NSW.

trimentula Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 111. (♂ HT, Pilliga East SF, NSW, S. Watkins, SAMA I 21526). V, NSW, Q.

tyrrhena Carter, 1923. *Proc. Linn. Soc. N.S.W.* **48**: 168. (♀ HT, Kalamunda, WA, H. M. Giles, AMSA K67293). WA

vicina Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 164. (♂ HT, Australie, Standing, BMNH). V, NSW, Q.

collaris Kerremans, 1903. *in Wytsman, Genera Ins. fas.* **12**: 229. (2 ♂♂ ST, Gayndah, Fairmaire, BMNH).

ornata Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 229. (♂ HT, NSW, Standing, BMNH).

violacea Kerremans, 1903. *in Wytsman Gen. Ins. fas.* **12**: 228. (♂ ST & ♀ ST, Gayndah, Fairmaire, BMNH). NSW, Q.

viridiceps Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 168. (♂ HT, Australie, Standing, BMNH). NSW.

viridipurpurea Carter, 1924. *Proc. Linn. Soc. N.S.W.* **49**: 27. (2 ♂♂ ST, Geraldton, WA, J. Clark, AMSA K67294). WA.

sapphira Carter, 1933. *Proc. Linn. Soc. N.S.W.* **58**: 163. (♀ HT, Moore R., WA, H. W. B., AMSA K67295)(new syn.).

watkinsi Barker, 2001. *Trans. Roy. Soc. S. Aust.* **125**: 112. (♂ HT, Tinonee Rd, Manning R., NSW, S. Watkins, SAMA I 21528). NSW.

westwoodi (Gory & Laporte, 1839)(*Coraebus*). *Mon. Bupr.* **ii**: 15. (♂ ST & 2 ♀♀ ST, MNHN). SA, V, T.

verna Blackburn, 1891. *Trans. R. Soc. S. Aust.* **14**: 299. (HT damaged sex unknown, Warburton District, Victoria, French collection, NMVA).

viridana Kerremans, 1898. *Ann. Soc. Ent. Belg.* **42**: 165. (♀ HT, Austral., Standing, BMNH).

theryi Kerremans, 1903. *in Wytsman Genera Ins. fas.* **12**: 229. (2 ♂♂ ST & 2 ♀♀ ST, Victoria, Théry, BMNH).

Discussion

C. adspersa Kerremans (HT not in BMNH) hab. India belongs in another genus.

C. albertisi Gestro is not a synonym of *C. acuducta* (Carter 1923) which does not occur at the tip of Cape York in the type locality.

C. cornuta Gestro (6 ST, MCSNG) = *Hypocisseis latipennis* Macleay.

C. duodecimguttata Guérin-Méneville, 1830 (*Buprestis*). Type species by subsequent designation (Duponchel, 1843).

C. fossicollis Kerremans (HT BMNH) = *Alcinous fossicollis* (Kerremans).

C. fulgidicollis Macleay is very uncommon in collections and has been confused with other species, particularly with *C. stellata* Barker.

C. gestroi Kerremans 1892, *Mem. Soc. Ent. Belg.* **1**: 225 is unknown to me; the holotype is not in the BMNH and the species is not listed under *Cisseis* in Kerremans (1903).

C. maculata Gory & Laporte was misidentified by Carter (1929) who listed *C. tasmanica* Kerremans and *C. pauperula* Kerremans as its synonyms; both are good species.

C. modesta Kerremans was listed as a synonym of *C. rubicunda* Kerremans Carter (1929). I find they are separate species.

C. nigrita Kerremans was listed as a synonym of *C. notulata* (Germar) by Carter (1929). Carter (1923) followed Blackburn's concept of *C. notulata,* which was incorrect. *C. nigrita* is a separate species.

C. nigripennis Macleay was listed by Carter (1923) as belonging in *Neospades.* I find it belongs in *Cisseis (s.s.).*

C. obscura Blackburn is a species that I have been unable to find in any available collection.

C. ovalis Carter could be a synonym of *C. opima* Thomson. The unique holotype is a discoloured female specimen.

C. rugiceps Thomson belongs in *Neospades.*

C. scabiosa (Boisduval) is unknown to me.

C. semiobscura Kerremans was listed as a synonym of *C. notulata* by Carter (1929). It is a separate species, much smaller than *C. notulata* and common in South Australia.

C. spilota Hope, 1846 (*Ann. Mag. Nat. Hist.* **17**: 64) (HT, HMOE not seen) is unknown to me. Hope indicated that it belonged in another

genus. Carter (1929) incorrectly listed it as a synonym of *C. signaticollis* Hope, 1846; *spilota* has precedence over *signaticollis*.

C. stigmata Gory & Laporte, 1839 selected as type species by Bellamy (1998) (invalid).

C. violacea Kerremans was listed as a synonym of *C. notulata* by Carter (1929). It is a separate, smaller species occurring in the vicinity of Brisbane, Queensland.

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THE FLORA AND FAUNA OF SOUTH AUSTRALIA HANDBOOKS COMMITTEE 10 MARCH 1921 – 30 OCTOBER 2001

WOLFGANG ZEIDLER

ZEIDLER, W. 2002. The Flora and Fauna of South Australia Handbooks Committee 10 March 1921 – 30 October 2001. *Records of the South Australian Museum* 35(1) 91–95.

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Manuscript received 13 December 2001.

The Flora and Fauna of South Australia Handbooks Committee has been operating for 80 years producing a series of handbooks on the major elements of the South Australian natural environment. The main role of the Committee was to encourage and persuade specialists to write books on the flora and fauna for no financial reward. The completed manuscripts were then edited by members of the Committee and, in the past, were printed by State Print or its equivalent and published by the State Government Printer at the State Government's expense. Several years ago this part of the Government's operations ceased, with no provision made for the further printing of handbooks.

Since the privatisation of the Government Printer the Committee has sought other means to publish its books and the last two handbooks have been printed with the help of the Board of the Botanic Gardens ('Fungi') and the SA Research & Development Institute (Aquatic Sciences) ('Marine Invertebrates III'). However, it became very clear to the Committee that the only way it could continue was to establish a publications fund.

Initially, the State Government was approached because of its traditional support for the Committee, but this proved fruitless, although the Department of Environment & Heritage and the South Australian Museum did offer some support if funds could also be found from other sources. Various philanthropic trusts were approached and, although some were sympathetic, no funding was forthcoming. Similarly, all three of the State's universities, whose students and staff are amongst the main users of the handbooks, declined to assist. The formation of a partnership with a publisher was also considered, but rejected as it would potentially compromise the original intention of the Committee because handbooks with commercial potential would be favoured.

Left with no alternative, the Handbooks Committee reluctantly concluded that it could not continue to function as originally intended and should be disbanded. The last meeting of the Flora and Fauna of South Australia Handbooks Committee was accordingly held on 30 October 2001.

With the demise of the Handbooks Committee, which was once the envy of all other states, it is important to record its history and major achievements.

The Committee began in 1921 when Prof E. Wood-Jones, Prof T. B. G. Osborn and Prof J. B. Cleland presented the idea to the then Premier Mr H. Barwell. The concept was for authoritative handbooks to be written by experts in their field without remuneration, to be published by the Government Printer at its convenience, and to be sold at a low price so as to be affordable to the wider community. Here follows an extract recording the foundation of the handbooks series, prefacing Eichler's (1965) 'Supplement to J. M. Black's Flora of South Australia'.

> After the first World War, the South Australian Branch of the British Science Guild was very active in devising ways for increasing scientific knowledge and its applications. At the time an up-to-date account of the Flora of our State was a pressing need. With this view, Professor J. B. Cleland suggested that the Science Guild might undertake to arrange for the preparation of a series of Handbooks dealing with the Fauna and Flora of South Australia. If these were prepared in an honorary capacity by leading authorities, the Government might well be asked to publish them, as it were, on a pound for pound basis. The Branch accepted the suggestion and it was arranged that a deputation of Professors F. Wood Jones, T. G. B. Osborn and J. B. Cleland should wait on the Hon. The Premier Mr., afterwards Sir Henry Barwell, with the proposal.

Fortunately Professor Cleland had prepared a memorandum on the subject in the following terms and this document was handed to the Premier on 25th February, 1921.

PROPOSED SCHEME FOR THE PREPARATION OF HANDBOOKS ON THE FAUNA AND FLORA OF SOUTH AUSTRALIA

I. There is an almost complete lack in South Australia of any handbooks dealing with the Fauna and Flora of the State.

II. In consequence, many individuals with scientific tastes are unable to develop these. This is a great loss to the State, as these persons, with suitable handbooks available, might be led on to contribute voluntarily to the State additions to scientific knowledge of great value to our pastoral, agricultural and other interests.

III. A scheme under the auspices of the S.A. Branch of the British Science Guild is proposed for the preparation of a series of such handbooks to be edited by a sub-committee of experienced workers, the individual parts to be prepared by specialists (in an honorary capacity).

IX. The scheme would be spread over a period of 10-15 years.

X. Parts would be issued as completed by the authors. None could be available during this financial year. One or two may be so for 1921-1922.

XI. The work involved will be highly skilled and laborious. In the interests of science the authors will be prepared, we believe, to devote their time and knowledge to this work without fee, if a means of publication can be obtained.

XII. The value to the community of the works of these authors, thus offered as a gift to the State and world of science, can be put at a very high figure. Would the Government be prepared to accept this offer of gratuitous service and as a return – on the "pound for pound subsidy" principle – arrange for the publication of the Handbooks by the Government Printer?

XIII. As the work will be spread over many years, this should not necessitate any additions to the staff of the Government Printer, the printing of the parts being proceeded with by him as opportunity offered. The actual out-of-pocket expense to the State would consist, under these circumstances, of the paper only. The parts as completed might be submitted to the Premier or to the Minister of Education, and laid on the table of the House and ordered to be printed and thus be dealt with as Parliamentary Papers.

IX. Many of the parts will require to be illustrated. In many cases, blocks are already prepared which doubtless could be used and so reduce expense.

X. The educational value of these handbooks will be great. A copy of each might be placed with advantage in every public school in the State, when it could be made available not only to teachers and scholars but to the public of the district as well. To meet this demand and to enable distribution to be made to private individuals (at a nominal price to induce the wide use of these handbooks) about 1,500 copies of each should be printed.

XI. Probably from 20 to 30 handbooks would eventually be published (over the period of 10-15 years), the sizes varying from about 20 to 150 pages according to subject matter.

Professor CLELAND, Adelaide University.
Professor WOOD JONES, Adelaide University.

The Premier read through the memorandum and said, "A very generous offer, gentlemen. I shall lay it before Cabinet." Professor Cleland received from the secretary to the Premier, a letter dated 10th March, 1921 in the following terms accepting the offer.

"With reference to the proposed scheme under the auspices of the South Australian Branch of the British Science Guild for the preparation of a series of handbooks on the Fauna and Flora of South Australia which was submitted by yourself and Professor Wood Jones to the Premier on the 25th ultimo, I am directed by the Premier to inform you that in consideration of the contributors in the compilation of the handbooks undertaking the work in an honorary capacity the Government is prepared to undertake the printing of the publication at the Government Printing Office at the expense of the State."

In recent years the Chief Secretary of South Australia decided that the Government Printer should publish the handbooks on a commercial basis, rather than that the Handbooks Committee should apply each year for a government grant for publication. Consequently there is now no delay in printing when the authors offer their completed manuscripts.

The British Science Guild has long since ceased to exist but the work of the Handbooks Committee survived until now. The main aim of the

Committee has always been to produce books that document, in a rigorously scientific way, the biological heritage of the State, although in recent years the Committee encouraged authors to broaden their focus to southern Australia in general. Perhaps the most outstanding work published by the Committee is the 'Flora of South Australia'. The remarkable J. M. Black produced the four-volume work single-handedly and revised the first three volumes, working until he was 96. Revision of the fourth volume was completed after his death. For South Australia's sesquicentenary a completely revised and rewritten new edition was produced, making this State the only one at the time to have a comprehensive up-to-date record of State flora.

There are also other monumental works for which other states have no equivalent (see list of handbooks) and, while some volumes are out of date, many have been updated or reprinted to meet the demand of scientists, naturalists and students. It seems remarkable that Hale's 'The Crustaceans of South Australia' (1927, 1929), reprinted in 1976, is still used as a basic text, although very much out of date and only providing a limited coverage of the group.

It is clear that the handbooks provide invaluable data for research workers, not only in South Australia, or even nationally, but internationally as well. Indeed, the handbooks series has been the envy of scientists in other states. Their contribution to secondary and tertiary education, as significant textbooks, is well recognised. For example, the four-part 'Flora', 'Fishes' and the three-part 'Marine Invertebrates of Southern Australia' series are essential texts for tertiary students. Unfortunately, the later volumes produced by the Government Printer were managed on a commercial basis and were remaindered within two years, so that they were only available for a relatively short period.

Future plans for new editions of 'Fishes', Amphibians', 'The Vegetation of South Australia', 'Crustacea' (as part of the 'Marine Invertebrates' series) and 'Flora' have been abandoned, although they may be taken up by others. In particular, the State Herbarium is in the process of producing an electronic version of the 'Flora', and the South Australian Research & Development Institute (Aquatic Sciences) intends to proceed with future volumes of the 'Marine Invertebrates' series as well as revising earlier volumes.

As part of the winding up process, the Committee has transferred copyright of the botanical texts to the Board of the Botanic Gardens and State Herbarium, and of the zoological and ecological texts to the Board of the South Australian Museum. Copies of correspondence and minutes of the Handbooks Committee have been deposited with State Archives.

Titles Issued By The Flora And Fauna Of South Australia Handbooks Committee

1922 'Flora of South Australia'. Part I. Cyathaceae – Orchidaceae. J. M. Black.
Second edition 1943. Reprinted 1948. Reprinted (facsimile) 1960, 1972. Third edition, Lycopodiaceae – Orchidaceae (revised by J. P. Jessop) 1978.

1923 'The Fishes of South Australia'. E. R. Waite.
Reprinted 1962.

1923 'The Mammals of South Australia'. Part I. The Monotremes and the Carnivorous Marsupials. F. Wood-Jones.
Reprinted in one volume with parts II (1924) and III (1925), with an Introduction by P. Crowcroft and a Selected Bibliography by J. H. Calaby 1968.

1924 'Flora of South Australia'. Part II. Casuarinaceae – Euphorbiaceae. J. M. Black.
Second edition 1948. Reprinted 1963. Reprinted (facsimile) 1977.

1924 'The Mammals of South Australia'. Part II. The Bandicoots and the Herbivorous Marsupials. F. Wood-Jones.
Reprinted in one volume with parts I (1923) and III (1925), as above, 1968.

1925 'The Building of Australia and the Succession of Life' with special reference to South Australia. Part I. W. Howchin.

1925 'The Mammals of South Australia'. Part III. The Monodelphia. F. Wood-Jones.
Reprinted in one volume with parts I (1923) and II (1924), as above, 1968.

1926 'Flora of South Australia'. Part III. Meliaceae – Scrophulariaceae. J. M. Black.
Second edition, Callitrichaceae – Plumbaginaceae 1952. Reprinted 1964. Reprinted (facsimile) 1977.

1927 'The Crustaceans of South Australia'. Part I. H. M. Hale.
Reprinted in one volume with part II (1929) 1976.

1928 'The Building of Australia and the Succession of Life' with special reference to South Australia. Part II. Mesozoic and Cainozoic. W. Howchin.

1929 'Flora of South Australia'. Part IV. Bignoniaceae – Compositae. J. M. Black. Second edition, Oleaceae – Compositae (revised by E. L. Robertson) 1957. Reprinted (facsimile) 1980.

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1929 'The Reptiles and Amphibians of South Australia'. E. R. Waite.

1930 'The Building of Australia and the Succession of Life' with special reference to South Australia. Part III. Pleistocene. W. Howchin.

1934 'Toadstools and Mushrooms and other Larger Fungi of South Australia.' General introduction; Toadstools and Mushrooms. J. B. Cleland. Reprinted in one volume with part II (1935), including 'Notes on some Edible and Poisonous Fungi' by P. H. B. Talbot, 1976.

1935 'Toadstools and Mushrooms and other Larger Fungi of South Australia'. Polypores, Coral Fungi and remaining Hymenomycetes; Puff-balls, Jelly-like fungi, the larger Ascomycetes and Myxomycetes. J. B. Cleland. Reprinted in one volume with part I (1934), as above.

1936 'The Seaweeds of South Australia'. Part I. Introduction and The Green and Brown Seaweeds. A. H. S. Lucas.

1937 'The Vegetation of South Australia'. J. G. Wood.

1938 'The Molluscs of South Australia'. Part I. The Pelecypoda. B. C. Cotton & F. K. Godfrey.

1939 'Primitive Insects of South Australia'. Silverfish, Springtails and their allies. H. Womersley.

1940 'The Molluscs of South Australia'. Part II. Scaphopoda, Cephalopoda, Aplacophora and Crepipoda. B. C. Cotton & F. K. Godfrey.

1947 'The Seaweeds of South Australia'. Part II. The Red Seaweeds. A. H. S. Lucas & F. Perrin.

1959 'South Australian Mollusca'. Archaeogastropoda. B. C. Cotton.

1961 'South Australian Mollusca'. Pelecypoda. B. C. Cotton.

1962 'The Marine and Freshwater Fishes of South Australia'. T. D. Scott.

1964 'South Australian Mollusca'. Chitons. B. C. Cotton.

1965 'Supplement to J. M. Black's Flora of South Australia' (second edition 1943–1957). H. J. Eichler.

1966 'Aboriginal Man in South and Central Australia'. Part I. Edited by B. C. Cotton. Only one part was published.

1972 'The Vegetation of South Australia'. R. L. Specht. Second edition.

1974 'The Marine and Freshwater Fishes of South Australia'. T. D. Scott, C. J. M. Glover & R. V. Southcott. Second edition. Reprinted (facsimile, with 16 pp of colour plates) 1980.

1975 'Plant Feeding and other Bugs (Hemiptera) of South Australia'. Heteroptera Part I. G. F. Gross.

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1978 'Butterflies of South Australia'. R. H. Fisher.

1978 'Amphibians of South Australia'. M. J. Tyler.

1979 'Lichens of South Australia'. R. B. Filson & R. W. Rogers.

1980 'Mosses of South Australia'. D. G. Catcheside.

1980 'Acacias of South Australia'. D. J. E. Whibley.

1982 'Marine Invertebrates of Southern Australia'. Part I. Edited by S. A. Shepherd & I. M. Thomas.

1984 'Psylloidea of South Australia'. F. D. Morgan.

1984 'The Marine Benthic Flora of Southern Australia'. Part I. H. B. S. Womersley.

1986 'The Dynamic Partnership: Birds and Plants in Southern Australia'. Edited by H. A. Ford & D. Paton.

1986 'Flora of South Australia. Volumes I–IV'. Edited by J. P. Jessop & H. R. Toelken. Fourth edition (third edition consisted of part I only).

1986 'The Ecology of Forests and Woodlands of South Australia'. Edited by H. R. Wallace.

1987 'The Marine Benthic Flora of Southern Australia'. Part II. H. B. S. Womersley.

1989 'Marine Invertebrates of Southern Australia'. Part II. Edited by S. A. Shepherd & I. M. Thomas.

1990 'Orchids of South Australia'. R. Bates & J. Z. Weber.

1992 'Acacias of South Australia'. D. J. E. Whibley & D. E. Symon. Second edition.

1994 'The Fishes of Australia's South Coast'. Edited by M. F. Gomon, J. C. M. Glover & R. Kuiter.

1997 'Larger Fungi of South Australia'. C. A. Grgurinovic.

1997 'Marine Invertebrates of Southern Australia'. Part III. Edited by S. A. Shepherd & M. Davies.

Dr Wolfgang Zeidler (Hon. Secretary), on behalf of the Flora and Fauna of South Australia Handbooks Committee — Em Prof William D. Williams (Chairman), Dr Sue Barker (Botanical Editor), Dr Margaret Davies (Zoological Editor), Dr Shelley Barker, Ms Robyn Barker, Dr John G. Conran, Mr Peter Copley and Dr Brian D. Morley.

OBITUARY

GRAEME LLOYD PRETTY

1940–2000

Graeme Pretty and Henry Pollach (left) at Roonka, 8 August 1971.
Roonka photos R83: 2. South Australian Museum.

Graeme Lloyd Pretty was born in Melbourne on 25 June 1940. His father was in the RAAF and the family soon moved to Richmond NSW, where Graeme spent his childhood and went to school. After graduating from Sydney University with a BA (Hons) in Classical Archaeology and Dip Ed, he contemplated undertaking a PhD with Jack Golson at the Australian National University. However, he began working at the South Australian Museum in January 1962 as Assistant Curator of Anthropology under Norman Tindale, from whom he learned much and with whom he kept in touch long after the latter's retirement. His first interest was in Melanesian prehistory—he might well have made this his major field of work.

In 1964 he was appointed Assistant Curator of Archaeology, and archaeological fieldwork was added to his duties. He excavated or assisted at a number of sites on the lower River Murray, seeking the advice of John Mulvaney who had recently excavated Fromm's landing. At the same time he continued research into Melanesian culture, including six weeks fieldwork in the Southern Highlands of Papua New Guinea (PNG) in 1968–69. Subsequently, he was invited to review the functions of the PNG Museum and Art Gallery. Later, he also advised the Australian National Gallery on its Melanesian collections.

In 1968 Pretty began a project that was to become the most important one of his working life. A salvage operation to remove a surface campsite and scattered human remains from a sandhill beside the River Murray at Roonka, near Blanchetown, developed into a major excavation that would attract worldwide interest. At that time he was unique in having consulted with the relevant Aboriginal group and obtained approval before beginning work—he continued this contact throughout and after the conclusion of the dig. This rapport with the Aboriginal people undoubtedly contributed to making possible the excavation on the scale and significance that was achieved.

Despite the disadvantages and difficulties of working on a surface fully exposed to gale-force winds and summer heat rising to the 50°C range, he retrieved a wealth of archaeological material and information from a site which proved to have been occupied for some 18 000 years. In all, 216 complete or fragmentary burials were uncovered. The grave goods were unprecedented at that time. In addition to almost every variant of human mortuary practice, it also gave evidence for hitherto undocumented customs, of which there were well over 150 examples.

Roonka looms large for its deep significance. Here is a statistical sample from one place, across some thousands of years, permitting health, injury and dietary studies of the population. Pretty correctly saw that aspects of the rituals involved—the mode of burial, including grave goods, and the antiquity of the rituals—presented a major window to past belief and behavioural systems. No other burial ground has produced so much evidence.

The almost exclusively amateur workforce of volunteers became, over the eight years of active fieldwork, a team of patient, dedicated, highly skilled excavators. Under Pretty's direction, the site was strictly controlled, meticulously recorded and kept secure from outside interference. The standard and scope of the work attracted substantial financial support as well as visitors from abroad, including osteo-archaeologists and a delegation from the People's Republic of China. One group will remember the visit not only for the archaeology but because their bus became bogged to the axles on the Roonka Flat.

Pretty was appointed to the position of Senior Curator of Anthropology and Archaeology in 1975.

The section of Pretty's work that has been best documented is probably that dealing with chronology. He had a critical appreciation of the role of physical dating methods in archaeology and sought to create a temporal framework for the finds at Roonka. The chronology of the site was determined by a larger number of different dating methods than any other archaeological site in Australia, including thermoluminescence, palaeomagnetism, uranium fluorimetry and C-14 dating, both conventional and AMS.

It is not generally known that he was responsible for planting the idea for developing luminescence dating in the Physics Department at the University of Adelaide in conversation with Professor John Prescott. This was in 1972, at the very infancy of the thermoluminescence technique. The earliest Adelaide work on thermoluminescence dating *per se* was based on samples from Roonka.

Pretty extended his fieldwork research to Island Melanesia in 1971 and 1973, finding additional support from sources outside Australia. However, the demands of attempting to elucidate the intricacies of the Roonka information, together with constraints on finance and staffing, resulted in the Melanesian work being put aside—apart from ongoing work, under his direction, on the sorting of the Foreign Ethnology reserve collections and their eventual rehousing at Kent Town in 1986. As Senior Curator of Archaeology, Pretty's work was directed almost exclusively to organising the mass of information from the Roonka site in order to arrive at what he considered an adequate assessment on which to base his final report. During the 1980s a master index of the Roonka data was prepared.

The Third Australasian Archaeometry Conference was held in Adelaide in 1988. Pretty devised the theme of the Symposium, 'Early Man in the Southern Hemisphere', which was designed to give a specifically archaeological balance to the program. He arranged invitations and finance for the international contributors: G. Delibrias, G. J. Bartstraa and H. J. Deacon; and organised the conference excursion and wrote the field notes.

In his own contribution to the symposium, a paper analysing the cultural chronology of Roonka, it is possible to see a foretaste of his overall interpretation of Roonka in its wider context. An early indication is also found in his exciting and innovative 1977 paper, 'The cultural chronology of Roonka Flat'. In it he remarked 'This present paper therefore celebrates the author's satisfaction that the archaeology is now sufficiently clear to commit preliminary notice of it to paper'. Yet, during the following 23 years, he produced no paper with the promised detail. It is difficult for those of us who knew him to avoid reflection on his apparent reluctance to put his ideas on paper where they could be exposed to the critical appraisal of his peers. He did publish sections of the work with his collaborators, but the overall synthesis was yet to come. Perhaps he was sensitive to possible criticism; perhaps the very volume of his material was an obstacle. It seems likely that he laboured over the precise language with which to present a polished final monograph.

In 1982 restructuring of the South Australian Museum's divisions and staffing made Pretty one of a number of Curators of Anthropology. He

accepted a severance package in 1994, continuing his work on the Roonka report until 1996, when he was stricken with viral encephalitis, from which he never fully recovered. He died on 6 November 2000.

In his work Pretty was patient, a seeker of precision in language that was baffling to many, and single-minded to a degree that ignored workplace relationships and, at times, made it difficult for people to work with him. His memory was exceptional. The breadth of his reading was remarkable and was reflected in his large personal library. He left the Museum's Foreign Ethnology collection well organised and totally accessible, and the Roonka material fully recorded and stored. He gained the respect of his field workers, instructing them in aspects of Aboriginal culture and inspiring in them a dedication and loyalty to the project that will ensure the publication of the final report.

Graeme married Dana in 1973 and they had one daughter. To those who knew him well he was a kind and considerate friend. At home he was a gracious and amusing host, an erudite and entertaining conversationalist, a devoted husband and a proud and loving father.

Authored And Collaborative Work To 1995, Listed By Field

Archaeology

PRETTY, G. L. 1964. Stone objects excavated in New Guinea. *Man* **64**, 138: 17.

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No. 8 SPIERS, G. K. 'Survey of Heritage Agencies in South Australia'.

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MUSEUM VICTORIA
26 NOV 2002

THE LARVAE OF SOME AUSTRALIAN AQUATIC HYDROPHILIDAE (COLEOPTERA: INSECTA)

CHS WATTS

WATTS, CHS. 2002. The larvae of some Australian aquatic Hydrophilidae (Coleoptera: Insecta). *Records of the South Australian Museum* 35(2): 105–138.

The larvae of the aquatic Hydrophilid genera *Allocotocerus* Kraatz, *Hybogralius* Orchymont and *Regimbartia* Zaitzev are described and figured for the first time. The larvae of the following Australian species are also described and figured, most for the first time: *Allocotocerus punctatus* (Blackburn); *Amphiops queenslandicus* Balfour-Browne; *Berosus australiae* Mulsant; *Enochrus eyrensis* (Blackburn), *E. mastersi* (W. MacLeay); *Helochares tristis* (W. MacLeay), *H. luridus* (W. MacLeay), *H. clypeatus* (Blackburn), *H. tenuistriatus* Regimbart, *H. foveicollis* (Montrouzier); *Hydrobiomorpha* sp.; *Hydrophilus bilineatus* (MacLeay); *Hybogralius hartmeyeri* (Regimbart); *Laccobius decipiens* Gentili; *Limnoxenus zealandicus* (Broun); *Regimbartia attenuata* (Fabricius); and *Sternolophus marginicollis* (Hope).

The larvae were identified by rearing larvae collected in the field, or occasionally by association and elimination, or by using biochemical methods.

The pupae of *Amphiops queenslandicus* and *Hybogralius hartmeyeri* are described and figured. Unlike most other Hydrophilids the larvae of *Amphiops* are thought to pupate exposed on the stems of emergent vegetation.

A key is provided to the larvae of Australian genera of aquatic Hydrophilids other than *Notohydrus* Balfour-Browne, *Paranacaena* Blackburn, *Phelea* Hanson and *Agraphydrus* Regimbart, whose larvae remain unknown.

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Manuscript received 23 April 2001.

The Hydrophilidae (sensu Hansen 1991) comprise a major part of the Australian aquatic beetle fauna, occurring in all types of fresh water and most commonly among vegetation at the edge of standing water. Adults and larvae occur together. The taxonomy of the adults is now relatively well known thanks to the work of Hansen (1991) at the generic level and above; and that of Gentili (1980, 1992, 1993, 2000) and Watts (1987, 1988, 1989, 1990, 1995, 1998a, 1998b) on the aquatic fauna at the species level. No recent work has been done on the species level taxonomy of the extensive portion of the family in which both adults and larvae are terrestrial.

In contrast to the situation with adults, the only work specifically on Australian larvae is that of Anderson (1976) who described the larvae of *Helochares tristis* (W. MacLeay), *Enochrus maculiceps* (W. MacLeay) and *Chasmogenus nitescens* (Fauvel) together with details of their life histories.

One feature of the Australian aquatic Hydrophilid fauna is its low endemicity at the generic level. Consequently, descriptions of a number of Australian genera are available in scattered Northern Hemisphere publications. The work on the New World genera was summarised and added to by Archangelsky (1997). This work included a number of genera which also occur in Australia.

For a number of years I have been rearing field-collected larvae of Australian aquatic Hydrophilids with the aim of discovering and describing the larvae of all genera and, for those already known from non-Australian species, to extend the descriptions to incorporate Australian species. The basic motivation was to produce a key to enable the larvae of all Australian aquatic Hydrophilidae to be identified at least to genus. As a result I have reared 12 species in 9 genera. Two additional genera, *Allocotocerus* and *Regimbartia*, were identified by associating adults and larvae by the biochemical technique of alloenzyme electrophoresis. Others were identified using the descriptions in Archangelsky (1997), eg *Hydrobiomorpha*; or by association and elimination, eg *Enochrus mastersi*.

I have not attempted any phylogenetic analysis

since, with such a high proportion of genera also occurring widely outside Australia, the only sensible approach would have been to include an examination of all known genera, which was beyond the scope of this study. Some comments on relationships are given under most generic descriptions.

In preparing this paper I have drawn heavily on the work of Archangelsky (1997) on the New World fauna. The descriptions follow his format and a number of the figures used to illustrate the key come from his important publication.

Although their larvae are known from other places, I have not seen Australian examples of the following genera: *Chaetarthria* Stephens, *Chasmogenus* Sharp, *Crenitis* Bedel, *Coelostoma* Brulle or *Paracymus* Thomson, and since I have nothing to add have not included descriptions. Detailed descriptions can be found in Archangelsky (1997). In addition, the larvae of *Paranacaena* Blackburn, *Notohydrus* Balfour-Browne, *Phelea* Hanson and *Agraphydrus* Regimbart are unknown.

Materials and Methods

Larvae were collected in the field and reared in small aquaria formed by placing the base of a small petrie-dish inside a larger petrie-dish and filling the space between them with damp sand (Watts 1963). Mosquito and chironomid larvae were the main food items provided. These were accepted by all larvae other than those of *Hydrophilus* (see under *Hydrophilus*). All species successfully reared pupated in cells constructed in the wet sand with the exception of those of *Amphiops* which pupated on the surface or attached to the sides of the container.

Larvae were preserved in 75% ethanol and examined under a stereomicroscope. Permanent microscope slides were prepared for detailed examination. Drawings were made with the aid of a camera lucida. Habitus drawings were only prepared when no previous illustration was available or when Australian species differed from those previously illustrated. Unless otherwise mentioned the descriptions are based on third instar larvae. Earlier instars usually differ somewhat, most noticeably in the stouter cephalic appendages and in fewer spines on the mentum. The key is constructed to accommodate all instars. Measurements of the head capsule were made under a stereoscopic microscope with a graduated eyepiece. Measurements of total length were made with dial callipers on both mounted and alcohol preserved material, but in this case the measurements can only be indicative as factors such as larval age and preservation effects can alter the length considerably. Measurements of the head capsule, particularly the width, are a more reliable indicator of size. Unless stated otherwise, the specimens were collected by myself and are in the collection of the South Australian Museum.

Systematics

KEY TO THE GENERA OF AUSTRALIAN AQUATIC HYDROPHILIDAE BASED ON LARVAL CHARACTERS

1) Not including the genera *Notohydrus, Paranacaena, Phelea* and *Agraphydrus,* whose larvae are not known.

2) Including *Spercheus* which is in the family Spercheidae but which has larvae that can be confused with Hydrophilidae.

1 — Tip of mandible bifid (Fig. 2g) .... Spercheidae (*Spercheus*)

— Tip of mandible not bifid .... Hydrophilidae...2

2 — Hypopharyngeal lobe well developed, like a pubescent tongue, originating at the base of the labium on the left side (Figs 2a, 2b) Subfamily Sphaeridiinae* .... *Coelostoma* Brulle

— Hypopharyngeal lobe reduced or absent ..... Subfamily Hydrophilinae...3

3 — Abdominal segments with long filamentous gills (Fig. 5a), or with multiple setose lateral projections on abdominal and thoracic segments (Fig. 15a) .... Tribe Berosini...4

— Lacking long filamentous abdominal gills or complex lateral projections, at most with simple short fleshy projections (Figs 4a, 14a, 16a) 6

4 — Gills long, without setae (Fig. 5a); labroclypeus asymmetric (Fig. 5b); mandibles asymmetric (Fig. 5f); prementum small and squat, without ligula (Fig. 5c), basal segment of antenna without lateral projection (Fig. 5e) .... *Berosus* Leach

— Abdominal and thoracic segments each with two or more setose, lateral projections

(Fig. 15a); mandibles nearly symmetrical (Fig. 15h); prementum long and thin, with ligula (Fig. 15d); basal segment of antenna with lateral projection (Fig. 15g) 5

5 — Body spines predominantly blunt, weakly bifid at tips (Fig. 3b); lateral projection on basal segment of antenna near apex, sharp, spine-like (Fig. 3f); apex of second segment of antenna with lateral extension (Fig. 3d); maxillary stipe without spines (Fig. 3e); ligula relatively short, prementum stouter (Fig. 3c) ..... *Allocotocerus* Kraatz

— Body spines predominantly pointed (Fig. 15c); lateral projection on basal segment of antenna thumb-like, further from apex (Fig. 15g), second segment of antenna without lateral extension (Fig. 15e); maxillary stipe with spines on inside (Fig. 15f); ligula relatively long, prementum more elongate (Fig. 15d) ..... *Regimbartia* Zaitzev

6 — Apical segment of antenna about same length as penultimate (Figs 12d, 16e); femora with fringe of swimming-hairs (Fig. 2h); with prostyles (two retractable, fleshy appendages on last abdominal segment) ..... Subtribe Hydrophilina...7

— Apical segment of antenna much shorter than penultimate (Figs 9e, 14e); femora lacking, or virtually lacking, swimming-hairs; without prostyles 9

7 — Labroclypeus without teeth (Fig. 12a); mandibles asymmetrical, left one very robust, right one more slender (Fig. 12e); ligula shorter than first segment of labial palpus (Fig. 12b); up to 40 mm long .... *Hydrophilus* Muller

— Labroclypeus with weak to moderate teeth (old specimens may lack teeth due to wear) (Figs 11e, 16f); mandibles symmetrical or nearly so; ligula longer than first segment of labial palpus (Figs 11b, 16c); up to 20 mm long 8

8 — Prementum longer than mentum (Fig. 16c); first segment of antennae with few spines (Fig. 16f); mandibles each with two large distal teeth and one small proximal denticle (Fig. 16f) ..... *Sternolophus* Solier

— Prementum slightly shorter than mentum (Fig. 11b); first segment of antenna with numerous spines on inside (Fig. 11c); mandibles each with one large distal tooth which is pick-shaped at the tip and one or two small proximal denticles (Fig. 11e) ..... *Hydrobiomorpha* Blackburn

9 — Left expansion of epistoma much more prominent than the right and with a row of stout setae on front edge (Fig. 13b); left mandible with group of stout setae at base of middle tooth which is lacking on the right mandible (Fig. 13f) 10

— Lateral expansions of epistoma similar, without a row of stout setae on front edge (Fig. 14b); mandibles without such a group of setae 11

10 — Frontal sulci parallel and not uniting to form a coronal sulcus (Fig. 13a); nasale with three teeth (Fig. 13b); prementum wider than long (Fig 13c); ligula absent or virtually so (Fig. 13c) ..... *Laccobius* Erichson

— Frontal sulci meet just before occipital foramen to form a coronal sulcus (Fig. 10a); nasale with five teeth (Fig. 10b); prementum longer than wide (Fig. 10c); ligula present though small (Fig. 10c) .. *Hybogralius* Orchymont

11 — Legs very short, without claws, prementum with a large round ligula (Fig. 2e); length up to 6 mm ..... *Chaetarthria* Stephens

— Legs usually longer, with claws. Prementum with or without ligula, but if present never large and round; length up to 15 mm 12

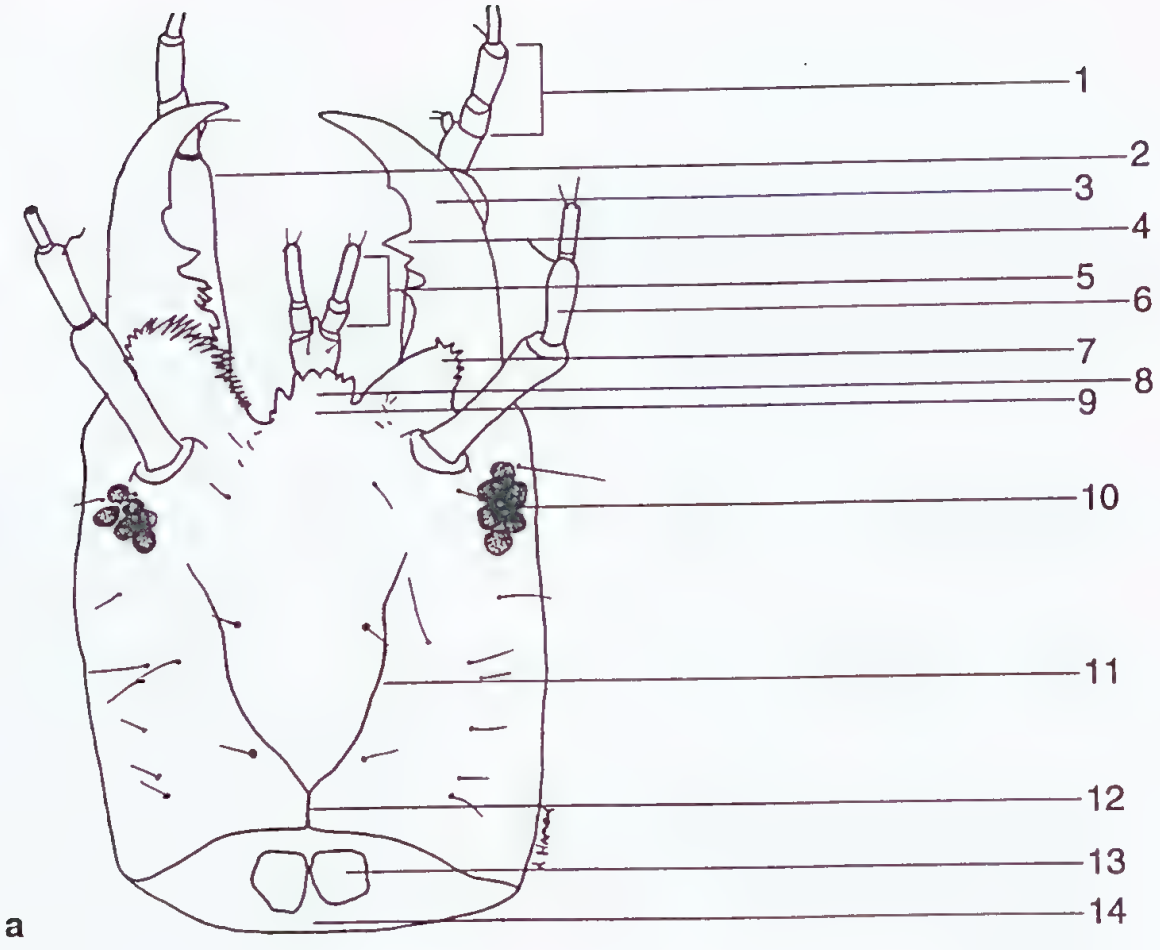
12 — Mentum large, wider than long, prementum small, lacking ligula (Fig. 4b) ..... *Amphiops* Erichson

— Mentum square or longer than wide, prementum well developed, ligula present (Figs 6b, 8b, 14c) 13

13 — All abdominal segments with dorsal sclerites, although often small; without coronal sulcus (Fig. 2c); length up to 6 mm; antennal appendage as long as apical segment; mandibles symmetrical with three teeth ..... Tribe Anacaenini....14

— Abdominal segments, other than 1 and 8, lacking dorsal sclerites; with short coronal sulcus (Fig. 1a); antennal appendage half length of apical segment (Fig. 8d); mandibles often asymmetrical and with fewer than three teeth; length up to 15 mm 15

14 — With lateral abdominal flaps (Fig. 2c); without cervical sclerites *Crenitis* Bedel



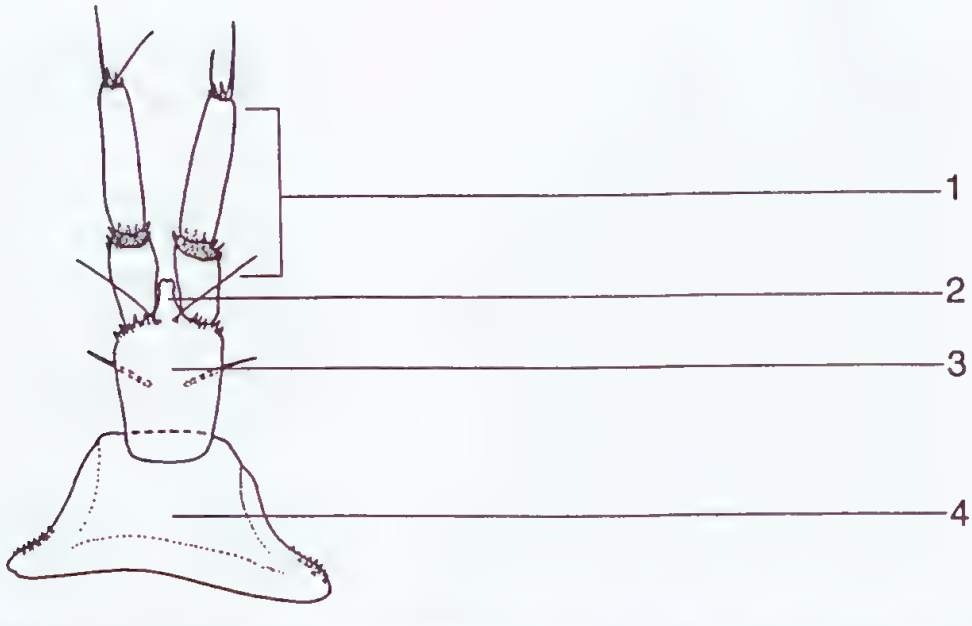


FIGURE 1. **a,** dorsal side of head capsule of *Hybogralius hartmeyeri*. 1, maxillary palpus; 2, stipes of maxillary palpus; 3, mandible; 4, mandibular teeth; 5, labium; 6, antenna; 7, right lobe of epistome; 8, teeth of nasale; 9, nasale (7 & 9 make up the labroclypeus); 10, stemmata; 11, frontal sulci; 12, coronal sulcus; 13, cervical sclerites; 14, occipital foramen; **b,** details of dorsal side of labium of *Hybogralius hartmeyeri*. 1, labial palpus; 2, ligula; 3, prementum; 4, mentum.

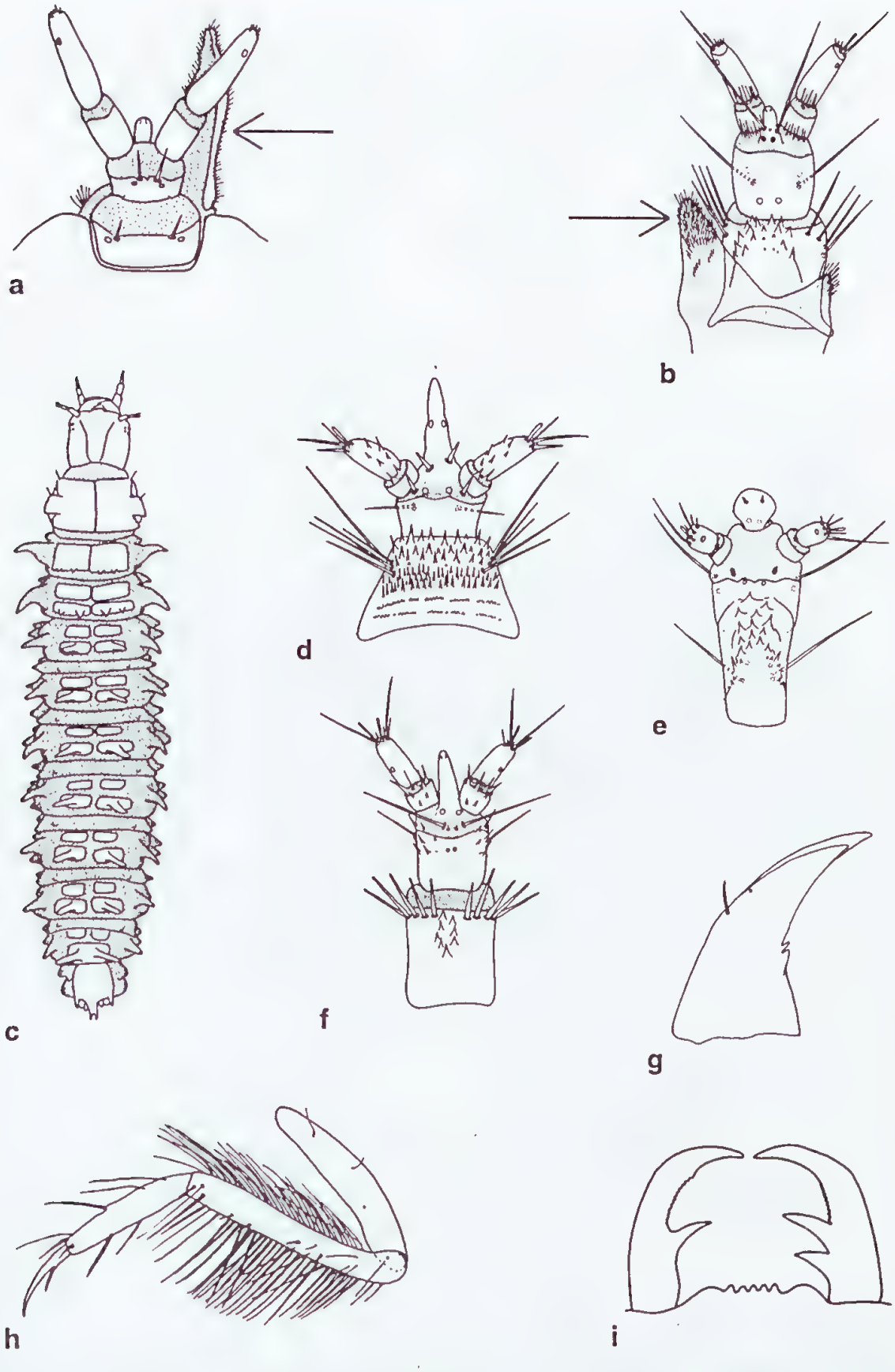


FIGURE. 2. **a**, ventral view of labium and hypopharyngeal lobe (arrowed) of *Sphaeridium scarabaeoides* (Linnaeus) (subfamily Sphaeridiinae); **b**, dorsal view of labium and hypopharyngeal lobe (arrowed) of *Dactylosternum* sp. (subfamily Sphaeridiinae); **c**, habitus of *Crenitis morata* (Horn); **d**, ditto, dorsal view of labium; **e**, ditto of *Chaetarthria* sp.; **f**, ditto, *Paracymus subcupreus* (Say); **g**, mandible of *Spercheus platycephalus* MacLeay; **h**, hindleg of *Hydrobiomorpha* sp., Northern Territory; **i**, labroclypeus and mandible of *Chasmogenus nitescens* (Fauvel). a–f, North American taxa from Archangelsky 1997; i, from Anderson 1976.

— Lacking abdominal flaps; with small cervical sclerites . *Paracymus* Thomson

15 — Apical segment of antenna about half length of penultimate (Fig. 14e); mandibles symmetrical with three teeth, without serrations (Fig. 14f) .... *Limnoxenus* Motschulsky

— Apical segment of antenna about a quarter the length of the penultimate segment (Fig. 8d); mandibles weakly to strongly asymmetric, with one or two teeth, often with serrations (Figs 6e, 8e) .... Subtribe Acidocerenia....16

16 — Nasale moderately developed, with right side more prominent (Fig. 6a) 17

— Nasale poorly developed, all areas equally prominent (Fig. 9b)..... 19

17 — Mandibles asymmetric, the right one with one tooth, left with two (Fig. 6e) ..... *Enochrus* Thomson (other than *E. mastersi*)

— Mandibles almost symmetrical, both with two teeth (Fig. 8e)..... 18

18 — Inside of maxillary stipe with group of spines near base (Fig. 8c); ligula longer than first segment of labial palpus (Fig. 8b); prementum approximately the same length as mentum (Fig. 8b)....*Helochares* Mulsant (other than *H. foveicollis*)

— Inside of maxillary stipe lacking such spines (Fig. 7c); ligula shorter than first segment of labial palpus (Fig. 7b); prementum approximately twice length of mentum (Fig. 7b) .... *E. mastersi* (W. MacLeay)

19 — First segment of antenna with bulge on inside near apex (Fig. 9e); mandibles each with two teeth (Fig. 8f) ....*H. foveicollis* (Montrouzier)

— First segment of antenna without bulge; right mandible with one tooth, left one with two (Fig. 2i) ....*Chasmogenus* Sharp

* Members of the subfamily Sphaeridiinae are predominantly terrestrial, occurring in moist situations such as dung and rotting vegetation. Members of only one genus, *Coelostoma,* are commonly found in aquatic situations in Australia.

Descriptions

The following descriptions are arranged in alphabetic order of the genera.

Allocotocerus Kraatz

Allocotocerus punctatus (Blackburn) Fig. 3

Size of third instar. Length 8.5–12.0 mm; head capsule, 0.70–1.00 mm long, 0.85–1.0 mm wide.

Head capsule. Subquadrangular, bulging outwards at anterolateral angles. Labroclypeus symmetrical; nasale very short, with numerous very short teeth on anterior border of epistome; lateral lobes of epistome rounded, very short. Frontal sulci straight, reaching from antennal bases to rear of head. Coronal sulcus absent. Gular sclerite absent. Cervical sclerites small, subrectangular, very weakly sclerotised.

Antennae. Three-segmented. First segment slender, longer than other two combined, with a spine-like inner process close to apex; third antennal segment short, connected to edge of the second segment before apex. Sensory appendage on second segment, slim, shorter than third segment.

Mandibles. Symmetrical, long and slender, with two inner teeth on basal half; distal tooth large, basal one small.

Maxillae. Five-segmented. Stipes slender, much longer than remaining segments combined, with two or three fine setae on inner margin. Palpus four- segmented; first and third segments subequal in length, first segment bearing a short inner process; second segment very short; fourth segment shorter than third.

Labium. Mentum large, subglobular, dorsal surface with some cuticular spines towards sides, anterolateral angles rounded with a few spines. Prementum much longer and narrower than mentum, subrectangular, longer than wide. Palpus two-segmented, basal segment short. Ligula about two times as long as basal segment of palpus, tip broadened.

Thorax and legs. Prothorax with broad dorsal sclerite, with sagittal line, surface covered by minute spines, fringe of long, slender setae around the margins and three short setae-bearing projections at sides; ventral surface with large, subrectangular sclerite, without sagittal line. Mesothorax with two dorsal pairs of subtriangular sclerites. Metathorax with one dorsal pair of irregular shaped sclerites. Both mesothorax and

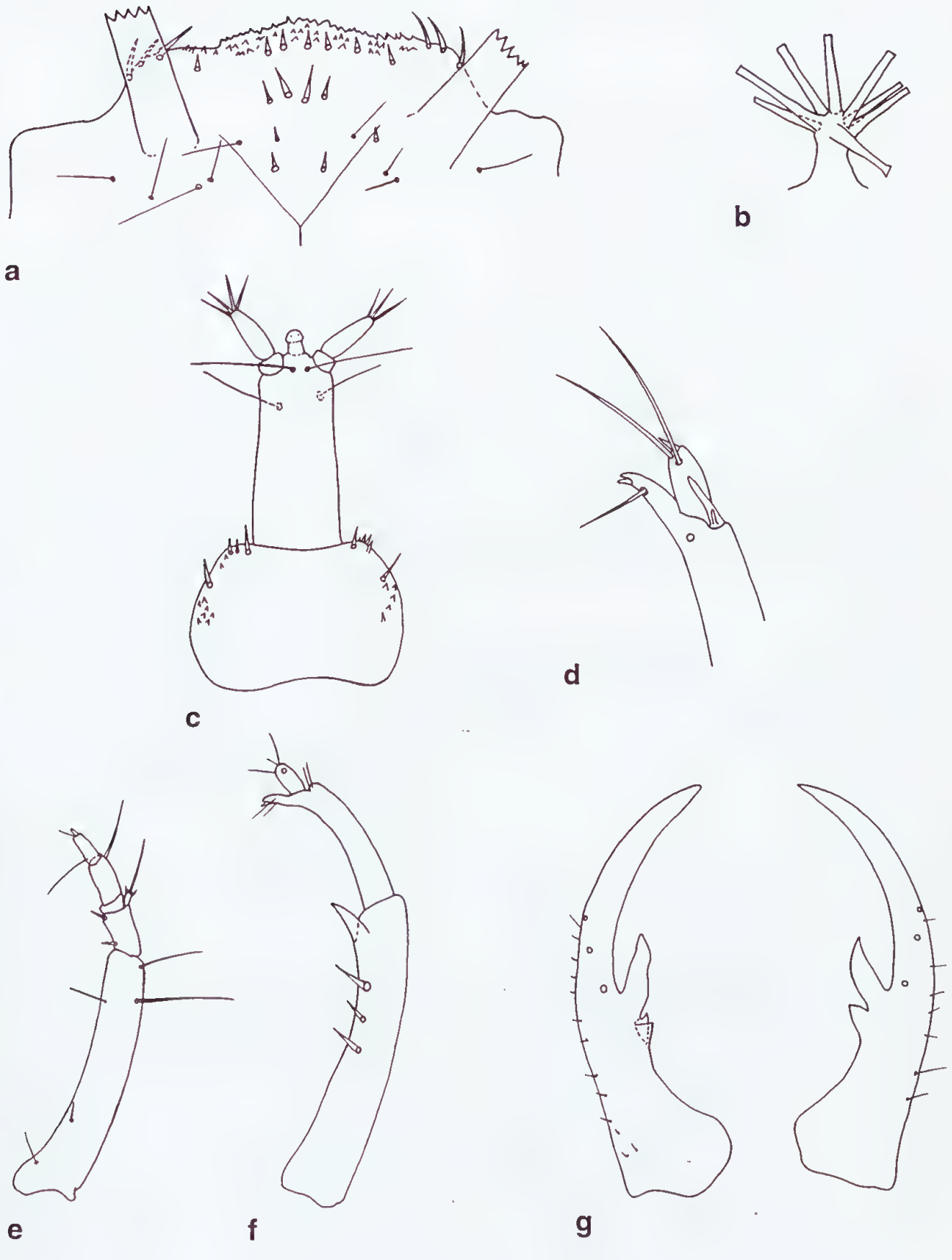


FIGURE. 3. *Allocotocerus punctatus.* **a**, labroclypeus; **b**, detail of abdominal stella; **c**, labium; **d**, tip of antenna; **e**, maxilla; **f**, antenna; **g**, mandibles.

metathorax with three lateral pairs of setiferous projections and a number of short setiferous papillae on dorsal surface. Legs five-segmented, long, visible from above.

Abdomen. Segments 1 to 7 with four pairs of setiferous projections similar to those on thorax, three on the side and a smaller dorsal one towards the midline. In addition, the abdomen is covered with minute, simple spines and the dorsal surface with small projections, each with six to eight, relatively long setae, truncated or weakly bifid at tips (in most specimens these structures are obscured by an accumulation of sand grains and detritus). Segment 8 without setiferous projections; with dorsal semispherical sclerite covering the spiracular atrium; with a pair of small finger-like 'procerci'. Segment 9 trilobed, with a pair of small, unsegmented urogomphi.

Spiracles. Mesothorax and abdominal segment 2 with pair of small non-functional spiracles on short papillae. (I have been unable to detect spiracles on other abdominal segments.) Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Interspecific variation

There is little variation among the few specimens seen — including one from the Northern Territory which is almost certainly *A. tibialis* (Balfour-Browne).

Identification

By association of adult and larva by isoenzyme electrophoresis.

Remarks

The larvae closely resemble those of the New World genus *Derallus* (Archangelsky 1997; Spangler 1966) in the setiferous body structures, form of the labroclypeus, mandibles, labium, maxillary palpi and antennae. The differences are small: blunt rather than sharp-pointed body spines, shape of the distal part of the antennae, number of spines on the maxillary palpi and details of the labium. The larva of *Allocotocerus* is also closely similar to those of *Regimbartia,* differing from this genus in the details of the same suite of characters. On balance it more closely resembles *Derallus.* Although placed by Hansen (1991) with *Berosus* in the tribe Berosini, on larval characters the three genera form a very distinctive and cohesive group well separated from *Berosus,* a conclusion reached by others (Bertrand 1972; Oliva 1992; Spangler 1966).

Specimens examined

Queensland: 2 km S Mt Molloy, 30/3/96. *Allocotocerus* sp. **Northern Territory**: Manton Dam, 23/3/98.

Amphiops Erichson

Amphiops queenslandicus Balfour-Browne. Figs 4, 17a

Size of third instar. Length 6.5–9.0 mm; head capsule 0.65–0.80 mm long, 0.78–0.82 mm wide.

Head capsule. Subquadrate. Labroclypeus symmetrical; nasale very short, with five small teeth; lateral lobes of epistome rounded, projecting further than nasale. Frontal sulci inversely bell-shaped, meeting before reaching occipital foramen. Coronal sulci very short. Gular sclerite absent. Cervical sclerites small, rectangular.

Antennae. Three-segmented. First segment as long as second; third half the length of second. Sensory appendage on second segment short, a quarter the length of the third segment.

Mandibles. Symmetrical with three inner teeth, the two distal teeth large and with slightly crotchet-shaped tips; third tooth much smaller.

Maxillae. Five-segmented. Stipes narrow, longer than the remaining segments combined, with a row of five to six small setae on inner margin. Palpus four-segmented; first segment elongate, rectangular, with inner process as long as very short second segment; third segment longer and narrower than first; fourth segment a little longer than second.

Labium. Mentum large, subrectangular, anterior edge with five to six large spines/protuberances, and numerous cuticular spines at sides towards base. Prementum ovoid, much smaller than submentum. Palpus short, two-segmented, basal very short, distal segment two to three times longer than basal one. Ligula absent.

Thorax and legs. Pro-, meso- and metasterna, almost completely covered by dorsal sclerites, each with a sagittal line. Ventral surface of prothorax with a subrectangular sclerite, subdivided by a sagittal line. Sclerites with very small spines arranged in short lines towards rear (only visible under high magnification). Bases of setae on sclerites pigmented. Legs five-segmented, moderately developed, visible in dorsal view. Dorsal surface with sparse covering of small dark patches.

Abdomen. First segment with dorsal pair of

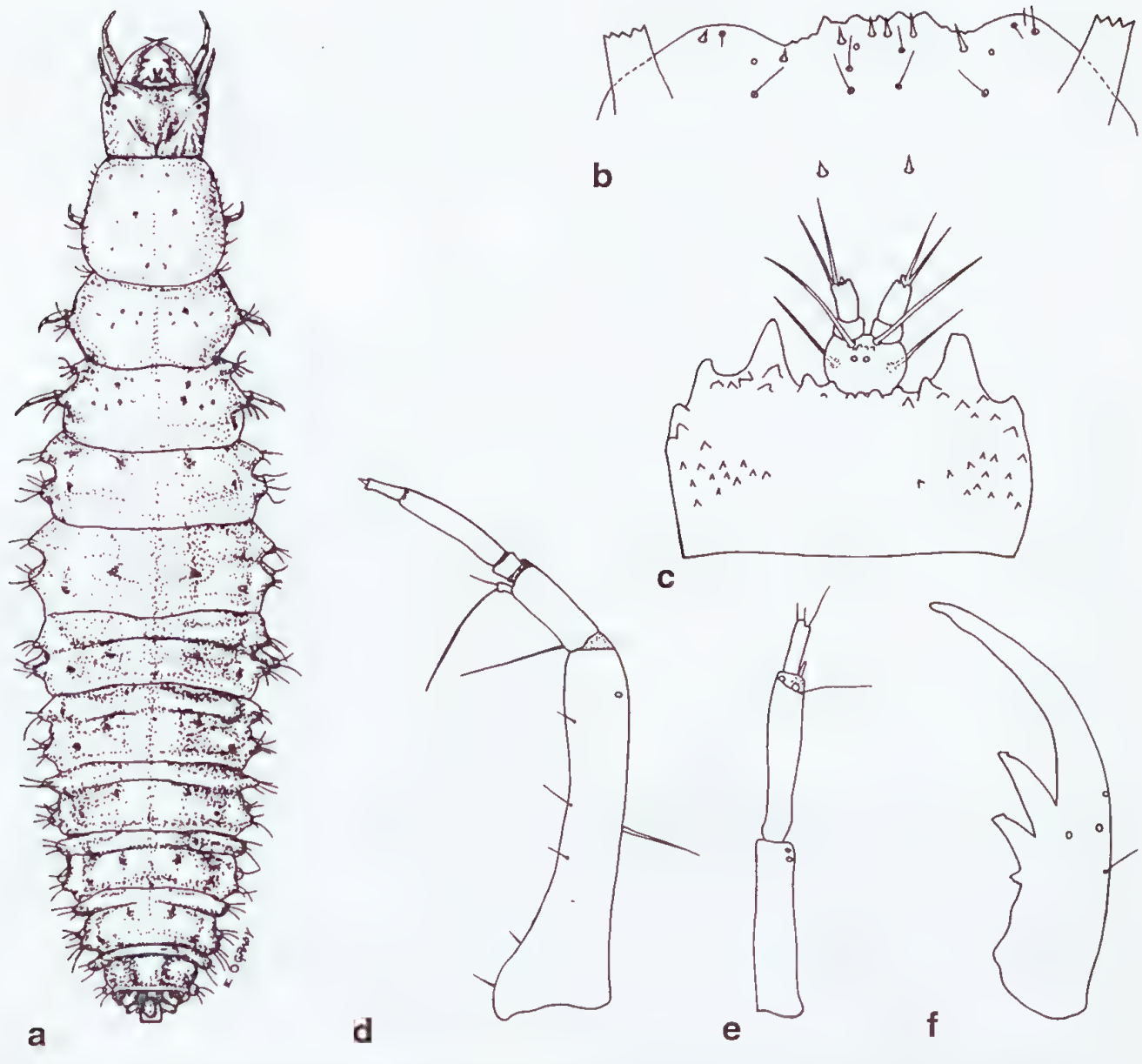


FIGURE 4. *Amphiops queenslandicus*. **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, maxilla; **e**, antenna; **f**, mandible.

moderate sized subtriangular sclerites, segments 2 to 5 with smaller dorsal sclerites, sclerites with scattered small darker patches. Segments 1 to 7 similar in size and shape, subdivided by a transverse fold; pleural areas with four pairs of moderate bulges/lobes each with several long setae at apex, ventral one largest; with a pair of small dorsal papillae, each with long terminal setae, abdominal surface strongly folded. Segment 8 with pair of small 'procerci', with a large dorsal, suboval sclerite; segment 9 trilobed, with a pair of small one-segmented urogomphi. Integument with only a few small spines.

Spiracles. Eight abdominal pairs; pairs 1 to 7 non-functional, on tips of small papillae and each with a long seta immediately inwards on a small cylinder-shaped base. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Pupa. (Fig. 17a)

Colour. Light to dark brown.

Head. With one pair of supraorbital styli; styli without apical setae. Appendages adpressed tightly to body, weakly differentiated externally.

Thorax. Pronotum with 16 styli, all on margins of pronotum. Mesothorax lacking obvious styli; metanotum with two pairs of styli, lateral ones near the base of wingpads very small, central pair prominent. Styli without setae. Wing cases grooved/ridged. Legs held tightly against body almost totally covered by pterothecae.

Abdomen. Segments 1 to 7 with a transverse row of four to five very small tergal styli on a sharp ridge that is stronger laterally. Segments 1 to 7 with well-developed rigid flap-like lateral extensions, those on segments 1 to 3 upright and slightly bent over inwards, those on segments 4 to 7 horizontal and each with a small stylus on posterior edge, each stylus with a small seta. Anterior edge of first tergite with very prominent, thin, rigid ridge. Segment 8 without obvious styli; segment 9 bearing a pair of medium-sized cerci.

Interspecific variation

There is little variation among the specimens of *Amphiops* available, although it is almost certain that several species are included. There are some differences, namely: the extent of the dorsal small dark patches/spots varies from a few to moderate numbers; the area between the abdominal sclerites and spiracles sometimes is a bit darker than rest; and there is some variation in the width of the nasale.

Identification

By rearing larvae collected in the field.

Remarks

Bertrand (1972) keyed out *Amphiops* larvae and briefly illustrated a presumed larva. Australian species appear to have less well-developed lateral abdominal protuberances than the specimen from the Indonesian Archipelago (Insulinde) illustrated by Bertrand (1972). Berge Henegouwen (1982) described an African species as having short conical outgrowths.

The noticeably lumpy sides to the abdomen, the very small prementum and labial palpi, and the lack of a ligula most readily identify specimens of *Amphiops.*

The form of the pupae is unusual, in particular the virtual absence of setae, the compact ventral surface and hard shield-like dorsal surface.

In the laboratory *A. queenslandicus* (and also *A. duplopunctatus,* of which a single larva was reared through to adult but the larval exuvium was lost) pupated above ground in the aquaria. This, together with the unusual shape and dark colour of the pupae, suggest that in the wild they pupate attached to the stems of emergent vegetation. Just how they physically attach themselves remains to be discovered.

Specimens examined

Queensland: 1 km W Mingela, 4/5/98.

Amphiops sp. **Northern Territory**: Jabiru, 21/3/98; 11 km E Jabiru, 19/3/98; Manton Dam, 23/3/98; Ormiston Gorge, 27/1/99. **Queensland**: 10 km S Cardwell, 7/2/97; 40 km S Cardwell, 7/2/97; 5 km NE Mt Molloy, 30/3/96; 2 km S Mt Molloy 30/3/96; Nardello's Lagoon near Mareeba, 29/3/96; same locality, 6/2/97; 10 km W Petrie, 23/11/95; 12 km NW Townsville, 8/2/97; 25 km S Townsville, 25/3/96.

Berosus Leach

Berosus australiae Mulsant. Fig. 5

Size of third instar. Length 6.5–1.05 mm (exclusive of gills); head capsule 0.75–0.95 mm long, 0.85–1.02 mm wide.

Head capsule. Subquadrate. Labroclypeus strongly asymmetrical; nasale narrow, strongly protruding, left of centre, with five to seven short teeth; lateral lobes of epistome asymmetrical, right one weakly projecting, left one strongly projected anteriorly, covering basal third of mandible, with several short, strong, curved spines. Frontal sulci lyriform, not coming together; absent on third instar larvae. Coronal sulcus absent. Gular sclerites absent, a pair of small, weakly sclerotised, cervical sclerites. With inverted U-shaped darker markings on dorsal surface.

Antennae. Three-segmented, relatively close together, arising just inwards of mandible bases. First segment a little longer than other two combined, with a stout subapical seta on inner margin. Sensory appendage on second segment, about half length of short third segment.

Mandibles. Slender, strongly asymmetrical; right mandible with large distal tooth and a very small central one; left mandible with group of seven small teeth or strong spines, some of which are bifid at tips.

Maxillae. Five-segmented. Stipes much longer than remaining segments combined, with four or five setae on inner margin. Palpus four-segmented; first segment short, subquadrate, with an inner process; second segment very short; third segment the longest; fourth a little longer than first.

Labium. Mentum short, poorly sclerotised. Prementum small, subquadrate. Palpus long, two-segmented, basal segment shorter than distal. Ligula absent or reduced to small bulge.

Thorax and legs. Prothorax with large dorsal sclerite, with sagittal line; ventral surface with a large subrectangular sclerite, hind edge strongly sinuate, with sagittal line. Mesothorax with two

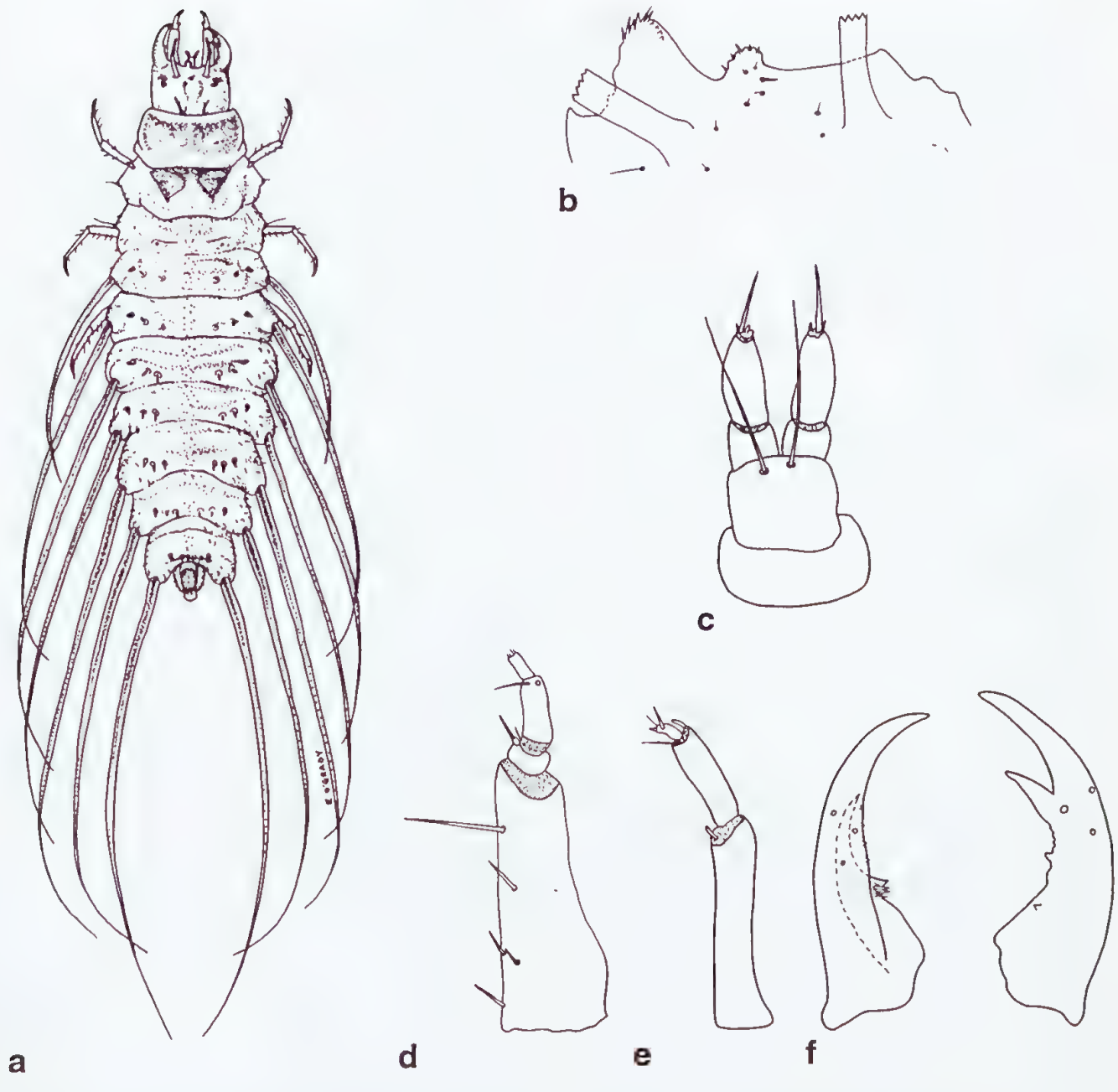


FIGURE 5. *Berosus australiae*. **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, maxilla; **e**, antenna; **f**, mandibles.

dorsal pairs of sclerites, inner pair small, outer pair much larger, subtriangular. Metathorax lacking sclerites. Mesothorax and metathorax with a pair of small lateral tubercles bearing a long apical seta. Legs five-segmented, long, visible in dorsal view.

Abdomen. Abdominal segments 1 to 7 subdivided by a transverse fold; each with a pair of long, lateral, tracheal gills, and two pairs of small cylindrical structures on dorsal surface in a line inward from spiracles. Segment 8 small, with a dorsal sclerite; spiracular atrium absent. Urogomphi reduced. Integument densely covered with small setae. Bases of gills with covering of small setae similar to those on adjacent abdominal segments. Each gill with a relatively long seta, arising from a small cylindrical base, towards tip. Dorsal surface often with darker patterning.

Spiracles. Nine pairs of non-functional spiracles, one mesothoracic and eight abdominal.

Intraspecific variation

There is some variation in the specimens I have identified as this species in the number and shape of the nasale teeth and in the presence/absence/strength of a dorsal colour pattern.

Interspecific variation

The description of *B. australiae* fits most of the specimens of *Berosus* that I have seen, many of which are unlikely to be *B. australiae*. I suspect that the description would fit the larvae of most species in the *B. australiae, B. majusculus* Blackburn, *B. veronicae* Watts group of Australian *Berosus*. There is some variation in colour and in the strength of setae on the integument (weak in *B. australiae*). Another group of specimens show clear differences from *B australiae*: the nasale is central rather than to the left; the integument is covered with small dark-pigmented patches in various patterns; the abdominal segments have variably sized, but often marked, colour pattern; there are finger-like projections on the sides of the prothorax and a differently shaped eighth abdominal segment. These larvae are associated with species such as *B. queenslandicus* Blackburn and *B. involutus* (W. MacLeay).

Identification

By association and elimination.

Remarks

The long filamentous lateral gills and the absence of functional spiracles readily identify larvae of *Berosus*. The asymmetry of the mandibles and labroclypeus, stout maxillae and lack of a ligula are also distinctive, but are characters shared variously by a number of other genera. Within Australian species there is no sign of the variation in the number of pairs of lateral gills seen in African (Bertrand 1972) and New World (Archangelsky 1997) species.

Specimens examined

Queensland: Bohle River, 10 km N Townsville, 23/3/96.

Berosus sp. **New South Wales**: 8 km N Bombala, 28/11/98; ditto, 3/11/97; Collector, 20/1/97; 5 km NE Dartmoor, 11/10/96. **Northern Territory**: Mt Borradaile Station, 26/5/99; Nawurlandja, Kakadu National Park, 29/1/99. **Queensland**: Burdekin River, 2/11/95; 10 K S Cardwell, 7/2/97; Jourama Falls, 31/10/95; 5 km NE Mt Molloy, 30/3/96. **South Australia**: 10 km N Coonawarra; 19/10/99. **Victoria**: Simpson Creek, 12 km SW Orbost, 16/1/97. **Western Australia**: Gin Gin, 15/10/96; 4 km S New Norcia, 15/10/96.

Enochrus Thomson

Enochrus eyrensis (Blackburn). Fig. 6

Size of third instar. Length 9.1 mm; head capsule 0.70–0.75 mm long; 0.75–0.80 mm wide.

Head capsule. Subquadrate. Labroclypeus asymmetrical; nasale obliquely truncate, left side shorter than right, with seven to nine short teeth, first two on right side and last one on left side largest; left lobe of epistome rounded, shorter than nasale; right lobe triangular, sharply pointed, about same length as nasale. Frontal sulci as an inverted bell, fusing just before reaching occipital foramen. Coronal sulcus very short. Gular sclerite absent. Cervical sclerites moderate, subrectangular.

Antennae. Three-segmented. In third instar first segment wider than second segment and about same length; second segment with small setae-bearing appendage on inside near middle; third segment about a third the length of the second. Sensory appendage on second segment much shorter than third segment.

Mandibles. Strongly asymmetrical; right mandible with two strong inner teeth on basal half; left mandible with one strong inner tooth. Inner margin of right distal tooth and distal parts of both mandibles serrated.

Maxillae. Five-segmented. Stipes wide, much longer than remaining segments combined, with four strong setae on inner margin. Palpus four-segmented; first segment subrectangular, a little wider that long, with an inner process a little shorter than second palpal segment; second segment short; third and fourth segments about twice as long as second, subequal in length.

Labium. Mentum subtrapezoidal, dorsal surface with two short stout spines in middle towards front, three strong spines laterally, anteriolateral angles each with a strong spine. Prementum squat, a little wider at base, shorter than mentum. Palpus two-segmented, first segment short, second segment approximately twice as long as first. Ligula slender, longer than first palpal segment, with partial ring of small spines around bases of palpal segments.

Thorax and legs. Prothorax completely covered by a dorsal sclerite, with sagittal line; two small very narrow sclerites on rear edge; front half of ventral surface with large sclerite with sagittal line. Mesothorax with large rectangular dorsal sclerite with sagittal line, with numerous strong setae; anterior half of metathorax with dorsal sclerite with sagittal line, posterior half with two

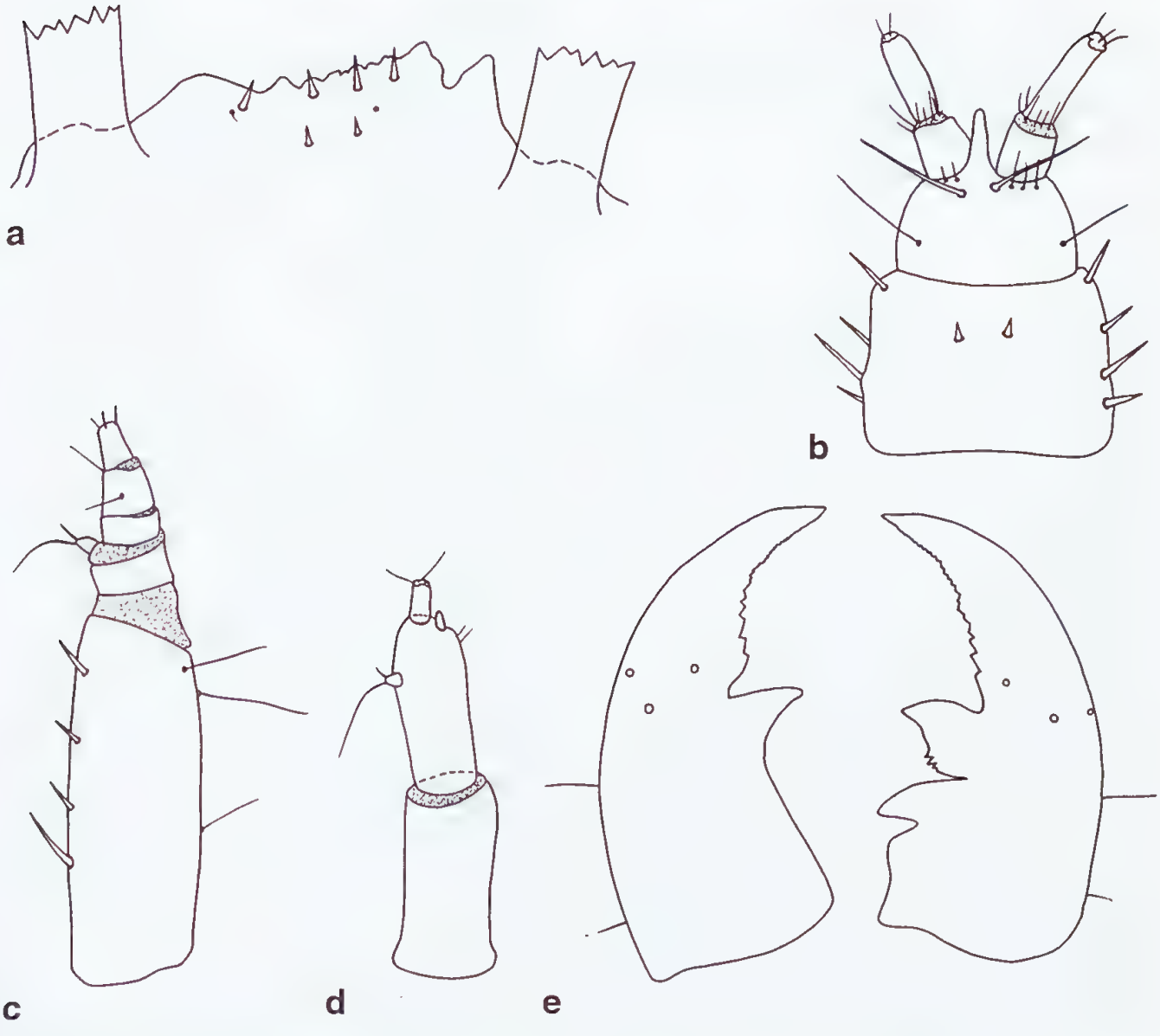


FIGURE 6. *Enochrus eyrensis*. **a**, labroclypeus; **b**, labium; **c**, maxilla; **d**, antenna **e**, mandibles.

small foot-shaped sclerites. Legs five-segmented, well developed, visible in dorsal view.

Abdomen. Segments 1 to 7 similar in shape and size, subdivided into three or four transverse folds; segment 1 with two dorsal pairs of small suboval sclerites, the anterior pair much the smaller. Segment 8 with a large, suboval, dorsal sclerite. Segment 9 trilobed, with a pair of short one-segmented urogomphi. Segments 2 to 7 with ventral pair of small protuberances covered with relatively strong, hooked setae (prolegs). Integument rather sparsely covered with small setae.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Intraspecific variation

No significant variation within the few specimens seen.

Interspecific variation

Within the few specimens available, which must include at least two additional species, there is some variation in the distribution of setae on the thoracic sclerites, in the number and relative size of the nasale teeth, and in the length of the ligula.

Specimens of *E. mastersi* differ more substantially in: pattern of setae on integument,

the presence of abdominal sclerites, lack of prolegs, the number of mandibular teeth, and the smaller and more distal lateral protuberance on the second antennal segment. The species is separately described below.

Identification

By rearing larvae collected in the field.

Remarks

The larvae of the Australian *E. (Methydrus) maculiceps* (MacLeay) (Anderson 1976) and *E. (M.) eyrensis* differ little from those of the North American *E. (Lumetus) ochraceus* (Melsheimer) (Archangelsky 1997) and *E. (L.) fimbriatus* (Richmond 1920, as *E. perplexus* (le Conte)) except possibly in a squatter mentum. *Enochrus (Hydatotrephis) mastersi* differs from all of the above by the nearly symmetrical mandibles and the lack of obvious setiferous prolegs, and from *E. (M.) eyrensis*, by the more elongate and spinose mentum. In these characters, other than the absence of prolegs, it more closely resembles larvae of the subgenus *Lumetus* than those of *Methydrus*.

All known larvae of *Enochrus* share with most *Helochares* the angled nasale. Apart from *E. mastersi*, they are readily separated from *Helochares* by the asymmetrical mandibles. *Enochrus mastersi* can be separated from *Helochares* by having the ligula shorter rather than longer than the basal segment of the labial palpus, in the lack of a basal patch of strong setae on the maxillary stipe, and in the presence of small dorsal sclerites on the abdominal segments.

Specimens examined

South Australia: 2 km S Penola, 10/99.

Enochrus sp. **Queensland**: Bohle River, 10 km N Townsville, 23/3/96; 30 km SE Townsville 4/5/98. **South Australia**: Mandina Lakes, 15/10/00; Tea Tree Gully, 7/5/97.

Enochrus mastersi (W. MacLeay). Fig. 7

Size of third instar. Length 12.0 mm; head capsule 1.30 mm long, 1.13 mm wide.

Head capsule. Subquadrate. Labroclypeus weakly asymmetrical; nasale obliquely truncate, left side shorter than right, with seven to eight short teeth, first two on right side and last one on left side largest; left lobe of epistome more rounded than right, shorter than nasale. Frontal sulci as an inverted bell, fusing before reaching occipital foramen. Coronal sulcus very short. Gular sclerite absent. Cervical sclerites small, subrectangular.

Antennae. Three-segmented. First segment wider than second segment, shorter than second in first instar larvae, about 1.5 times as long as second in third instar larvae, slightly bulging on inner apical corner; third segment about a third the length of the second. Sensory appendage on second segment much shorter than third segment.

Mandibles. Weakly asymmetrical; right mandible with two strong inner teeth on basal half; left mandible with one strong inner tooth and one much weaker tooth. Inner margins of distal teeth and distal parts of mandibles serrated.

Maxillae. Five-segmented. Stipes wide, much longer than remaining segments combined, with four strong setae on inner margin. Palpus four-segmented; first segment subrectangular, as wide as long, with an inner process a little shorter than second palpal segment; second segment short; third and four segments slightly longer, subequal in length.

Labium. Mentum rectangular, dorsal surface with scattered cuticular spines and several strong spines at front and side edges. Prementum rounded, a little wider at base, shorter than mentum. Palpus two-segmented, first segment short, second segment 1.0–1.5 times longer than first, some small spines at the bases of both segments. Ligula slender, as long as first palpal segment.

Thorax and legs. Prothorax completely covered by a dorsal sclerite, with sagittal line, with numerous relatively long setae; ventral surface with two subrectangular sclerites. Mesothorax with a pair of large dorsal sclerites with irregular posterior margins, covered with relatively long setae. Metathorax with narrow pair of dorsal sclerites each with a small foot-shaped backward extension, covered with relatively long setae. Legs five-segmented, well developed, visible in dorsal view.

Abdomen. Segments 1 to 7 similar in shape and size, subdivided into three or four transverse folds; segments 1 to 6 with a dorsal pair of small suboval sclerites. Segment 8 with a large, suboval, dorsal sclerite. Segment 9 trilobed, with a pair of short one-segmented urogomphi. Integument covered with dense, small setae, in many places organised into tight bundles.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

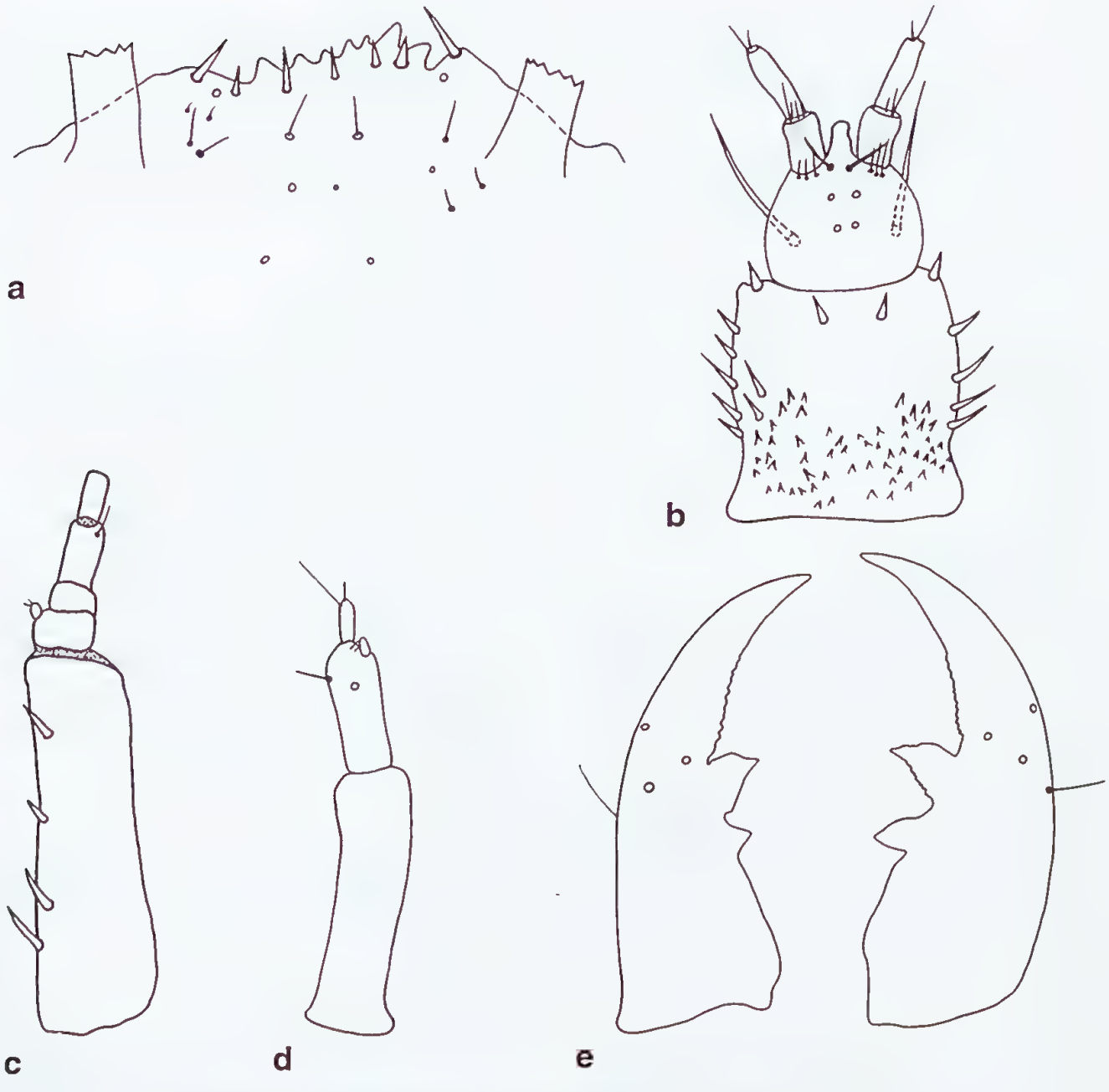


FIGURE 7. *Enochrus mastersi*. **a**, labroclypeus; **b**, labium; **c**, maxilla; **d**, antenna; **e**, mandibles.

Intraspecific variation

Only three specimens are known. They vary slightly in size of the abdominal sclerites but otherwise are very similar.

Interspecific variation

See under *E. eyrensis*.

Identification

By association and elimination.

Specimens examined

New South Wales: Salisbury, 26/11/95. **Northern Territory:** Ormiston Gorge, 27/1/99. **Victoria:** King Parrot Creek, 2/12/98.

Helochares Mulsant

Helochares tristis W. MacLeay. Fig. 8

Size of third instar. Length 6.8–10.0 mm; head capsule, 0.53–0.56 mm long, 0.66–0.69 mm wide.

Head capsule. Subquadrate. Labroclypeus asymmetrical; nasale obliquely truncate, shorter on left side, with six small teeth; lateral lobes of epistome project nearly as far as nasale. Frontal sulci inversely bell-shaped, meeting before reaching occipital foramen. Coronal sulcus very short. Gular sclerite absent. Cervical sclerites narrow, subrectangular.

Antennae. Three-segmented. First segment as

long as second (first instar larvae) or longer (second and third instar larvae); second segment with a slim apical sensory appendage on inside which is half the length of third segment; third segment much smaller than second.

Mandibles. Slightly asymmetrical; two inner teeth in middle, distal one larger on left mandible, only slightly larger on right mandible. Distal inner margin and inner margins of teeth slightly serrated. Distal part of teeth darker.

Maxillae. Five-segmented. Stipes wide, longer than remaining segments combined, with a row of four stout setae on inner margin, base with a tuft of strong spines. Palpus four-segmented; first segment subrectangular, with an inner process a little longer than the second palpal segment; second segment the shortest; third segment longest; last segment slightly shorter than third.

Labium. Mentum large, subquadrate, with dorsal surface covered by strong cuticular spines. Prementum subrectangular, wider than long. Palpus two-segmented, basal segment very short, distal segment three to four times longer than basal; a few small spines at base of apical segment. Ligula about twice as long as first palpal segment.

Thorax and legs. Prothorax almost completely covered by a dorsal sclerite, with sagittal line; ventral surface with a subrectangular plate, with a sagittal line. Mesothorax with a pair of large rectangular dorsal sclerites; metathorax with a pair of small dorsal sclerites, irregular in shape, composed of a wide and narrow basal portion and an L-shaped central portion arising from the middle of the basal piece. Legs five-segmented, well developed, visible in dorsal view.

Abdomen. Segment 1 with two dorsal pairs of small, narrow, irregularly shaped sclerites; anterior pair much smaller. Segments 1 to 7 similar in size and shape, subdivided by three or four transverse folds; pleura of segments 1 to 7 with three longitudinal slight bulges, the most ventral one in three lobes, each segment with a dorsal pair of setae towards the middle arising from a small circular sclerite or dark-pigmented area, and a small seta a little inwards and backwards from each spiracle. Segment 8 with a large, suboval, dorsal sclerite, serrate on posterior edge and pair of short apical flaps. Segment 9 trilobed; with a pair of small one-segmented urogomphi; central lobe largest. Integument densely covered in short fine setae.

Spiracles. Nine pairs; one mesothoracic and eight abdominal, raised slightly above the surface. Mesothoracic and first seven abdominal spiracles non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Intraspecific variation

There is some variation in the shape of the thoracic sclerites and in the shape and configuration of the nasale teeth.

Interspecific variation

H. luridus (W. MacLeay) and *H. clypeatus* Watts. As for *H. tristis.*

H. tenuistriatus Regimbart. The integument is predominantly covered by long thin setae rather than the short and very curved setae found in *H. tristis, H. luridus* and *H. clypeatus.* This gives a distinct furry look to the larvae.

H. foveicollis (Montrouzier). Differs in lacking nasale, having a slight bulge on the inside of antenna and a number of other characters (see below). These differences are sufficient to warrant a separate description (see below).

Other *Helochares* species. Within specimens unidentified to species there is variation in: form of the small setae on the integument; the shape of the metasternal sclerites; and the presence/absence, position and shape of the abdominal sclerites.

Identification

H. tristis, H. luridus and *H. clypeatus* by rearing larvae collected in the field; *H. tenuistriatus* by association and elimination.

Remarks

Within the known Australian *Helochares* larvae there are clearly two groups: *H. foveicollis;* and *H. tristis, H. luridus, H. tenuistriatus* and *H. clypeatus.* These correspond to the subgenera *Helochares* and *Hydrobaticus* Blackburn, respectively, and strongly reinforce the distinctiveness of these groups as reflected in the classification. Within Australian *H.* (*Hydrobaticus*) there is very little difference between the known species or among the large number of unidentified larvae. In addition, there is minimal difference between these Australian *H.* (*Hydrobaticus*) and the North American *H.* (*Hydrobaticus*) *maculicollis* Mulsant (Archangelsky 1997; Richmond 1920) or the South American *H.* (*Sindolus*) *talarum* Fernandez) and *H. (Helochares) pallipes* (Brulle) (Fernandez 1983) or the European *H. (Helochares) obscurus* (Muller) (as *griseus* Heer) (Boving & Henriksen 1938).

The larvae of *H.* (*Helochares*) *foveicollis* differ

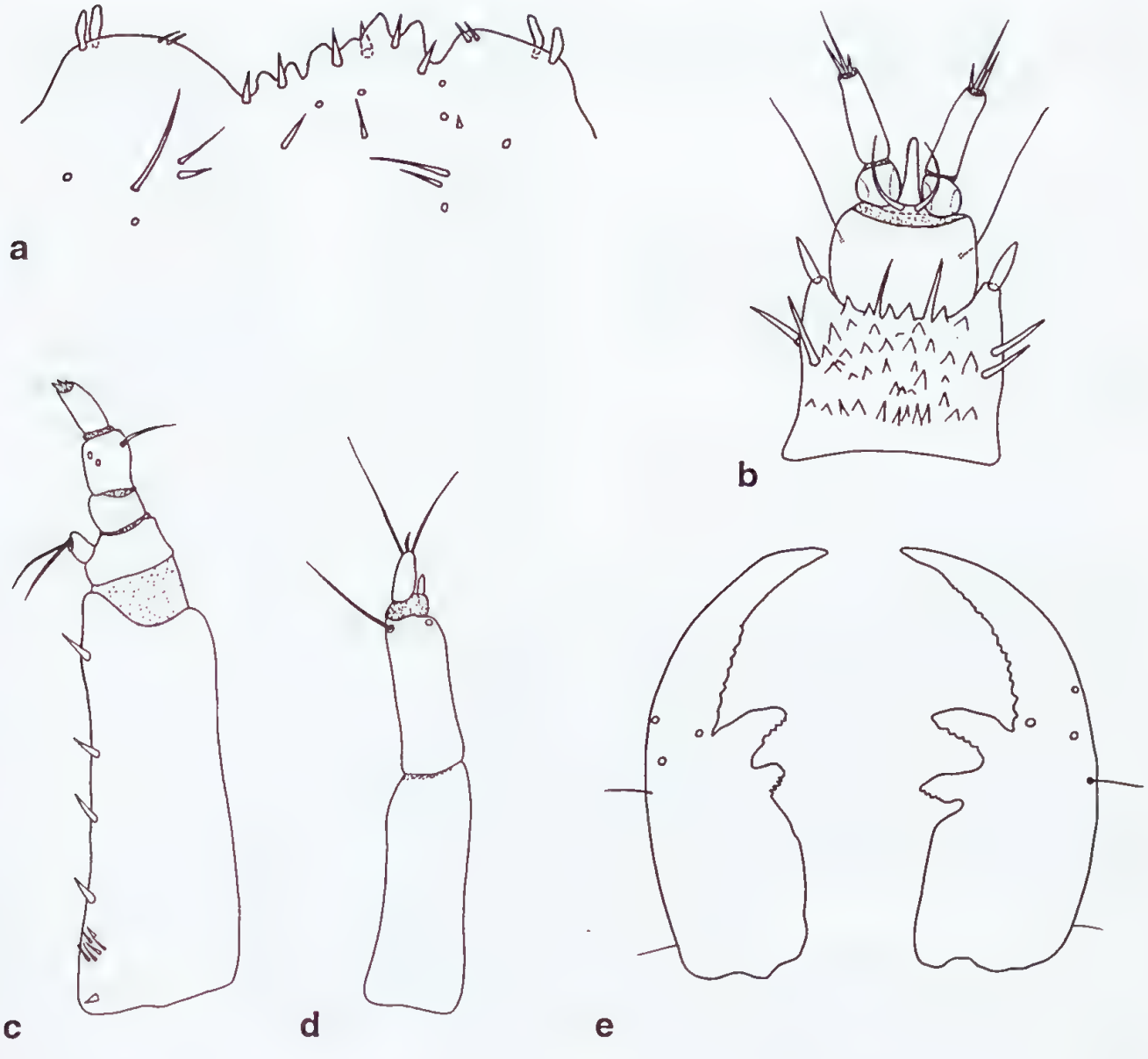


FIGURE 8. *Helochares tristis*. **a**, labroclypeus; **b**, labium; **c**, maxilla; **d**, antenna **e**, mandibles.

considerably from all of these species in a number of characters, most noticeably the symmetrical labroclypeus and the more elongate antennae and maxillary palpi (see later).

The larva of the related Australian genus, *Chasmogenus*, is only known from the work of Anderson (1976). It also has a symmetric labroclypeus but differs from both *H.* (*Helochares*) *foveicollis* and *H.* (*Hydrobaticus*) *tristis* in the asymmetric mandibles, one with one tooth and the other with two, and in the complete rather than partial dorsal sclerites on the metathorax.

Species of *H.* (*Hydrobaticus*) appear to breed more or less continuously and females are frequently caught with egg masses attached to their abdomens, although Anderson (1976) found that there was a distinct spring breeding season in *H. tristis* near Sydney. Larvae are among the most commonly collected Hydrophilid larvae, often found together with those of *Limnoxenus* in the south and both *Limnoxenus* and *Sternolophus* in the north. They can be readily separated from both of these by their angled nasale and mandibles with two rather than three teeth.

Although adults of *Enochrus* are often more common than those of *Helochares*, their larvae are, for unknown reasons, rarely found. They share with *H.* (*Hydatotrephis*) the angled nasale but, other than *E. mastersi*, have strongly asymmetrical mandibles. Larvae of *E. mastersi* resemble those of *H.* (*Hydatotrephis*) quite closely

but differ in lacking a cluster of strong setae at the base of the maxillary palpus, and in having the ligula shorter than the basal segment of the labial palpus.

Specimens examined

New South Wales: 20 km W Nelligan, 3/11/97. **South Australia**: 10 km N Coonawarra, 26/9/98; Cudlee Creek, 10/11/96; Kuitpo, 5/10/95; 13 km W Meadows, 26/9/96; Mt Crawford State Forest, 10/11/96; Tea Tree Gully, 7/5/97. **Victoria**: 10 km W Cowwarr, 30/11/98; Healsville, 12/68.

H. tenuistriatus. **Western Australia**: 30 km N Perth, 14/10/96

H. clypeatus. **Northern Territory**: Nourlangie Creek, 20 km SSW Jabiru, 11/10/98.

H. luridus. **Queensland**: Burdekin River E of Charters Towers, 4/5/98.

Helocharus sp. **New South Wales**: 12 km E Tamworth, 26/11/95. **Northern Territory**: Nawurlandja, Kakadu National Park, 22/3/98. **Queensland**: Alligator River 20 km S Townsville, 25/3/96; Bluewater, 22/3/96; Bowling Green Bay National Park, 6/11/95; 10 km N Cairns, 4/1/97; Eubenangee Swamp, 4/2/97; 8 km S Greenvale, 27/3/96; Jourama Falls near Townsville, 31/10/95; 1 km W Mingela, 4/5/98; Star River, 1/11/95; 30 km SE Townsville, 4/5/98.

Helochares foveicollis (Montrouzier). Fig. 9

Size of third instar. Length 13.5 mm; head capsule 0.78 mm long, 0.94 mm wide.

Head capsule. Subquadrate. Labroclypeus symmetrical, without nasale; with eight to nine small teeth along front edge in middle; lateral lobes of epistome slight. Frontal sulci inversely bell-shaped, meeting before reaching occipital foramen. Coronal sulcus short. Gular sclerite absent. Cervical sclerites small, subrectangular.

Antennae. Three-segmented. First segment as long as second (first instar larvae) or longer (second and third instar larvae), with distinct protruberance on inside near apex; second segment with a slim apical sensory appendage on inside, half the length of third segment; third segment much thinner than second.

Mandibles. Relatively slim, symmetrical; two inner teeth in middle, distal one much larger. Outer margin of apical tooth weakly serrated.

Maxillae. Five-segmented. Stipes relatively narrow, much longer than remaining segments combined, with a row of five stout setae on inner margin, base with a few short, strong spines. Palpus four-segmented; first segment subrectangular with an inner process as long as the second palpal segment; second segment the shortest; third segment the longest; fourth segment shorter than third.

Labium. Mentum large, subquadrate, with central portion of dorsal surface covered by weak cuticular spines and a semicircle of six spines, anterolateral angles sharp, each with a small spine. Prementum elongate–rectangular, longer than wide. Palpus two-segmented, basal very short, distal segment four to five times longer than basal one. Ligula short, thick, about twice the length of first palpal segment.

Thorax and legs Prothorax almost completely covered by a dorsal sclerite, with sagittal line; ventral surface with a subrectangular sclerite, subdivided by a sagittal line. Mesothorax with a pair of large dorsal sclerites; metathorax with a pair of small dorsal sclerites composed of a wide and narrow basal portion and an L-shaped portion arising from the middle of the basal piece, 'heel' reaching posterior margin. Legs five-segmented, well developed, visible in dorsal view.

Abdomen. Segments 1 to 7 similar in size and shape, subdivided by three or four transverse folds; segment 1 with two dorsal pairs of small narrow basal sclerites, the anterior pair smallest; pleura of segments 1 to 7 each with three to four weak longitudinal bulges, a well separated pair of strong dorsal setae arising from a very small circular darkly pigmented area, a moderately strong seta just inwards and behind each spiracle. Segment 8 with a large, suboval, dorsal sclerite with a ragged hind edge, and a pair of prominent apical flaps; segment 9 trilobed, central lobe largest and sclerotised, with a pair of prominent one-segmented urogomphi. Integument covered with moderately dense hair-like setae.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles very small, non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Intraspecific variation

Among the few specimens known there is some variation in the number of larger spines on the mentum and in wear on the nasale teeth.

Interspecific variation

Helochares foveicollis differs from other known Australian *Helochares* larvae by the lack of a nasale, presence of a prominent bulge on the

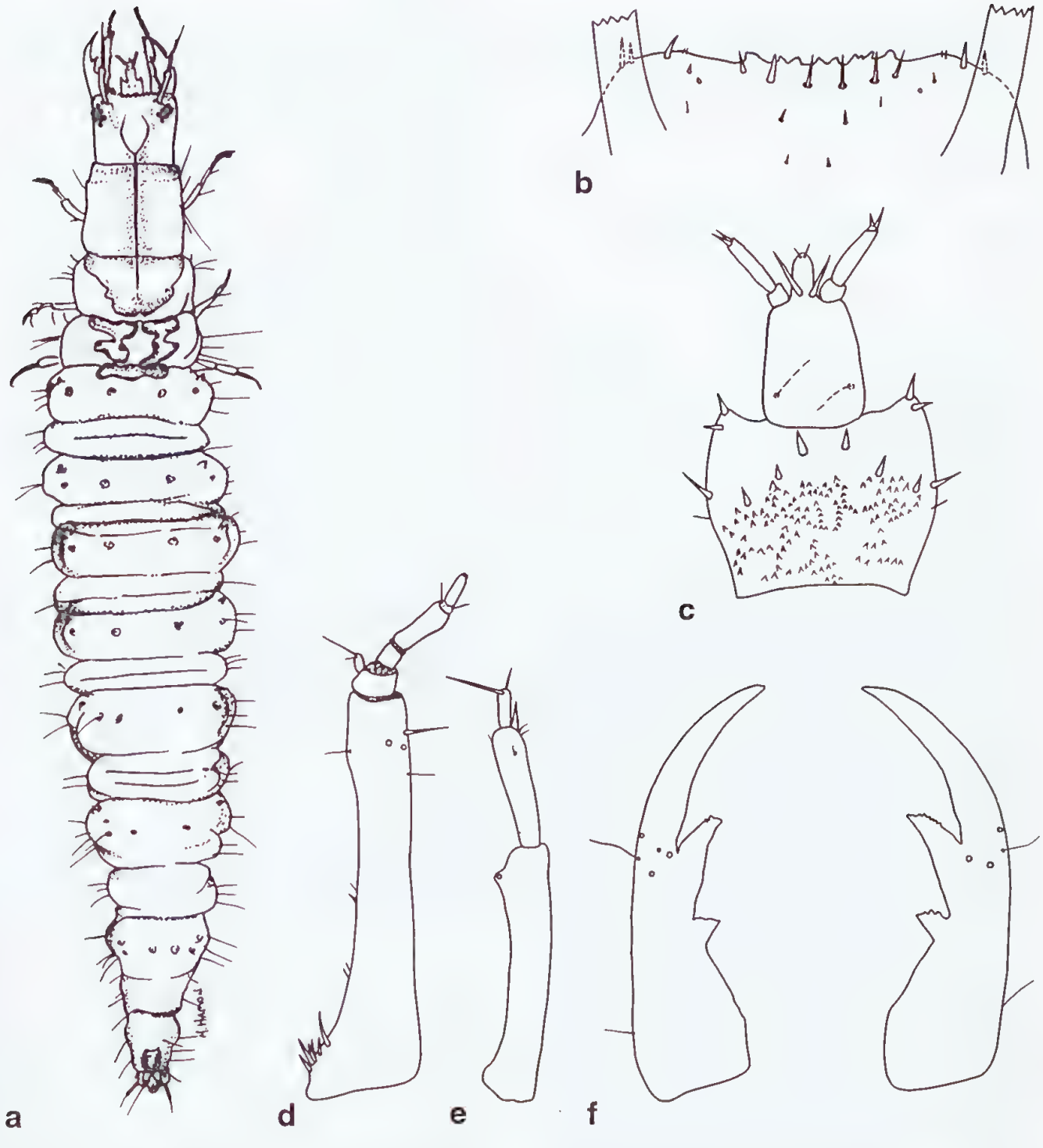


FIGURE 9. *Helochares foveicollis*. **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, maxilla; **e**, antenna; **f**, mandibles.

inside of the antennae, proportionally longer and narrower prementum and ligula, more elongate maxillary palpi and the shape of the metathoracic sclerites (Fig. 9).

Identification

By rearing field-caught larvae and rearing from egg mass attached to female.

Remarks

On adult characters *H. foveicollis* is presently placed in the subgenus *Helochares* together with *H. obscurus* and *H. pallipes*. However larval characters do not support this placement, nor its placement in either of the subgenera *Hydatotrephis* or *Sindolus*.

Specimens examined

Northern Territory: Manton Dam, 2/2/99; 2 km S Adelaide River, 1/2/99. **Queensland**: 40 km S Townsville, 2/2/97.

Hybogralius Orchymont

Hybogralius hartmeyeri (Regimbart). Figs 10, 17b

Size of third instar. Length 10.0 mm; head capsule 1.60–1.79 mm long, 1.62–2.00 mm wide

Head capsule. Rectangular. Labroclypeus asymmetrical; nasale narrow, projecting well forward, with five teeth, the two lateral ones more distant than rest; lateral lobes of epistome rounded, projecting farther than nasale, left lobe often larger, with a strong comb of stout spines on front edge, front edge of right lobe with a few scattered spines. Frontal sulci U to V-shaped, fusing just before reaching occipital foramen. Coronal sulcus short. Gular sclerite absent. Cervical sclerites relatively small, subrectangular.

Antennae. Three-segmented. First segment longer than remaining segments combined; second segment about 1.5 times the length of third segment which is very thin. Sensory appendage on second segment minute.

Mandibles. Asymmetrical; right mandible with three inner teeth, the anterior one largest; left mandible with three teeth of approximately the same size, central one with patch of strong setae at base.

Maxillae. Five-segmented. Stipes stout, longer than remaining segments combined, with four long stout setae on inner margin. Palpus four-segmented; first segment widest, with a short inner process; second segment short; third segment longest; fourth segment about half length of third.

Labium. Mentum small, subrectangular, sides slightly convex, dorsal surface with small spines, anterolateral angles rounded with several stout spines. Prementum elongate, rectangular, as long as mentum. Palpus two-segmented, first segment the shortest. Ligula present, about as long as the first palpal segment, tip weakly bifid.

Thorax and legs. Prothorax with large dorsal sclerite, with sagittal line; ventral surface with a large subrectangular sclerite, with sagittal line. Mesothorax with a pair of large triangular dorsal sclerites. Metathorax with a pair of semicircular dorsal sclerites and a more posterior pair of much smaller circular ones. Sclerites, particularly the anterior ones, covered with very short spines, occasionally arranged in short rows; rest of thorax densely covered with short fine setae with a few much longer setae laterally. Legs five-segmented, relatively short, just visible in dorsal view.

Abdomen. Segments 1 to 8 similar in shape, tapering towards the caudal end; Segments 1 to 7 subdivided into three or four transverse folds; sides of each segment with some slight, fleshy bulges, with one to two long setae. Segment 8 with two transverse folds, without dorsal sclerite. Segment 9 with hind margin weakly concave. Below segment 9, and projecting just beyond, are two prominent broad lobes. Integument densely covered with small fine setae.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles on small papillae. Spiracles on segment 8 (if present at all) obsolete and certainly non-functional.

Pupa (Fig. 17b). Head without styli. Pronotum with 22 styli, 16 around margins and 6 on disc. Mesonotum and metanotum each with one pair of styli near the midline. Abdominal segments 1 to 7 with a row of four styli on the terga, segments 2 to 7 with one stylus on each pleuron; segment 8 without styli; segment 9 with a pair of long urogomphi.

Intraspecific variation

One specimen has a slight mandibular tooth anterior to the normal ones (Fig. 1); otherwise, there is little variation other than in tooth wear between the few known specimens.

Identification

By rearing from larvae collected in the field.

Specimens examined

Western Australia: Gooseberry Hill, 14/9/00.

Remarks

Hybogralius is a monospecific Australian genus known only from a couple of localities in the escarpment region of the Darling Ranges east of Perth, Western Australia where it lives in small temporary winter/spring streams. Although placed with *Limnoxenus* in the subtribe Hydrobiina of the tribe Hydrophilini (Hansen 1991), the larvae of the two genera have little in common. Several features of the larvae of *Hybogralius* stand out: the lack of a spiracular atrium, the strongly asymmetric labroclypeus, the narrow prominent nasale, the strongly asymmetrical mandibles, and the rings of small spines at the base of the

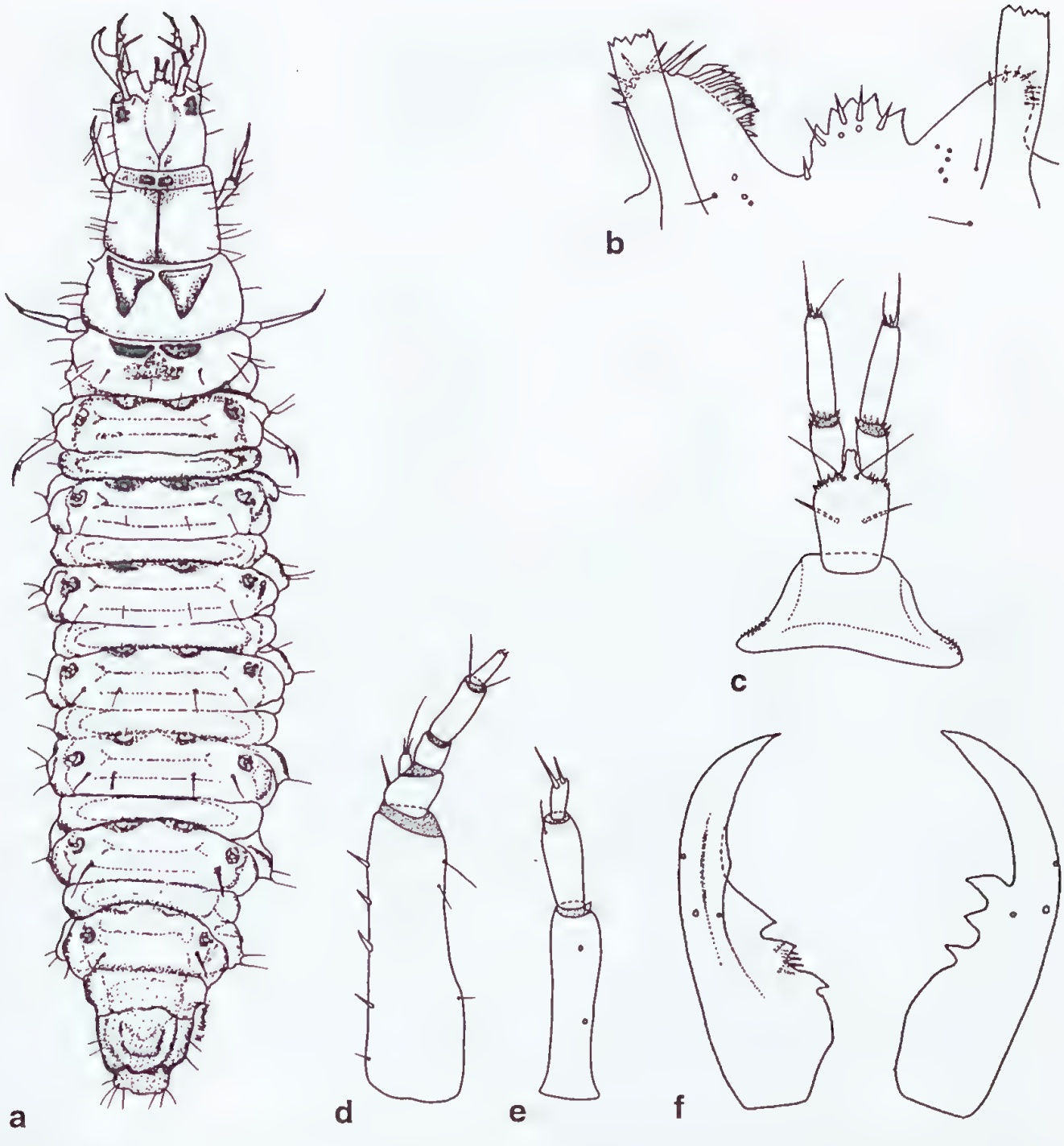


FIGURE 10. *Hybogralius hartmeyeri* **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, maxilla; **e**, antenna; **f**, mandibles.

segments of the labial palpi. In most of these characters it most closely resembles *Berosus*. Apart from the lack of a spiracular atrium and the presence of a coronal sulcus, it also resembles the larvae of *Oocyclus* Sharp and *Laccobius* in the tribe Laccobiini. To what degree these similarities reflect phylogenetic relationships remains to be seen.

As well as the lack of a functional apical spiracle, the main tracheal trunks are narrower than most other genera and the spiracles are not much larger, if at all, than those of other genera where they are considered non-functional. How the larvae manage to breathe is a puzzle.

Hydrobiomorpha Blackburn

Hydrobiomorpha sp. Fig. 11

Size of third instar. Length 15.0 mm; head capsule 1.65 mm long, 1.70 mm wide.

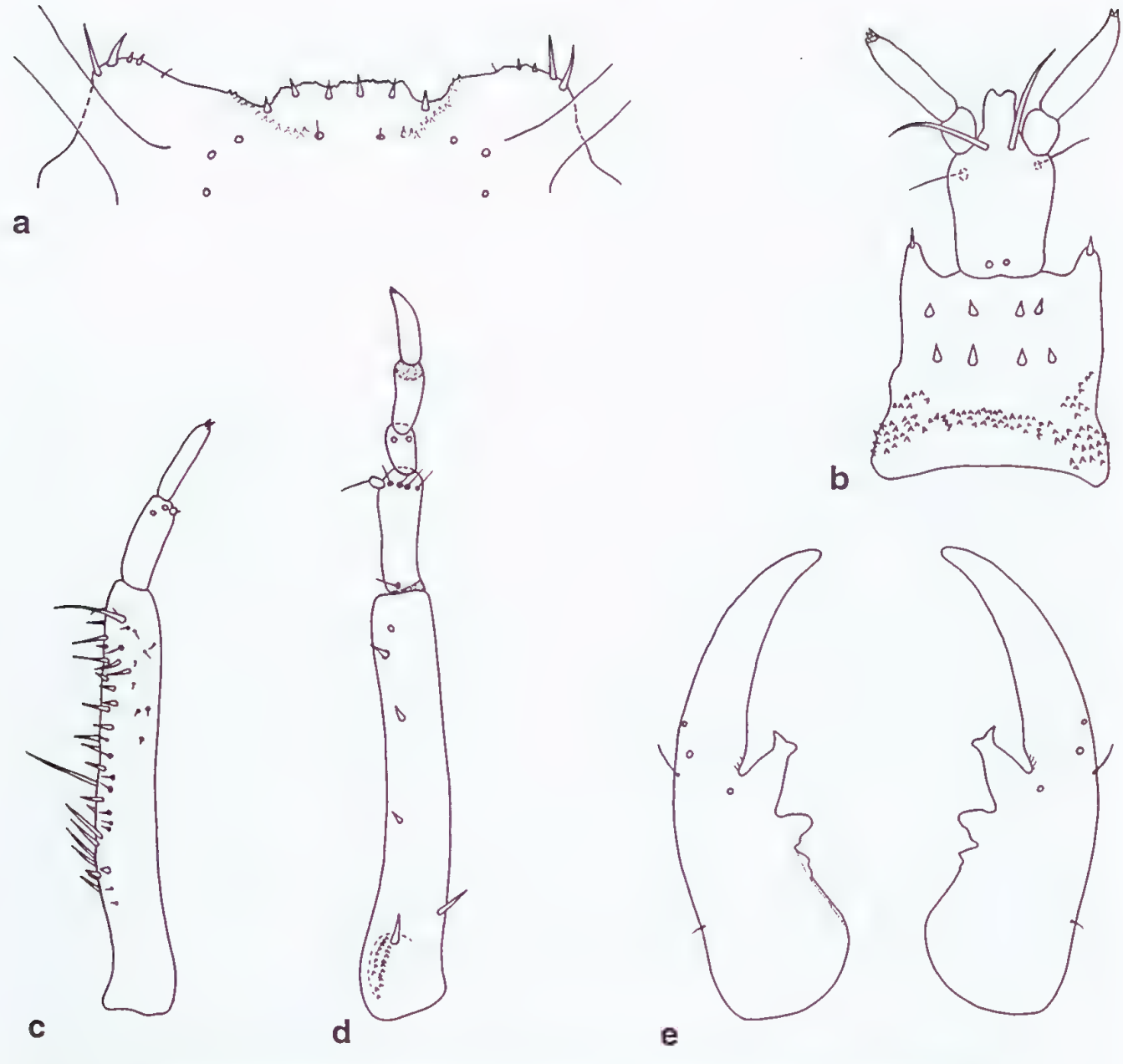


FIGURE 11. *Hydrobiomorpha* sp. **a**, labroclypeus; **b**, labium; **c**, maxilla; **d**, antenna; **e**, mandibles.

Head capsule. Subquadrate. Labroclypeus slightly asymmetrical; nasale truncate, edge rough rather than toothed; lateral lobes of epistome rounded, projecting further than nasale. Frontal sulci V-shaped, meeting before reaching occipital foramen. Coronal sulcus short. Gular sclerite absent. Cervical sclerites small, subquadrate. Numerous small darker patches on posterolateral angles and within frontal sulci.

Antennae. Three-segmented. First segment slender, three times longer than remaining segments combined (third instar larvae), inner margins with numerous short spines; second segment as long as third. Sensory appendage of second segment very small.

Mandibles: Symmetrical, sharply pointed; right mandible with three teeth on basal half, distal one large, bifid apically, central tooth smaller, basal one much smaller; left mandible similar to right except for basal tooth placed slightly more ventrally.

Maxillae. Five-segmented. Stipes slender, longer than remaining segments combined, with a group of short spines on inner margin at base, and several setae along inner and outer margins. Palpus four-segmented; first segment longest, with a short inner process; second segment the shortest; third and fourth segments subequal in length, each twice as long as second segment.

Labium. Mentum approximately square,

anterolateral angles projected, each with a pair of very small spines; dorsal surface with eight short, stout setae on distal two-thirds, and short cuticular spines on basal third. Prementum longer than wide, half the width of mentum. Palpus two-segmented, distal segment three to four times longer than basal segment. Ligula a little longer than first palpal segment, weakly bifid.

Thorax and legs. Prothorax covered by a large dorsal sclerite, posterior end rounded, sagittal line present; ventral sclerite large, subrectangular, with sagittal line. Mesothorax with pair of irregularly shaped sclerites, wider anteriorly, with sagittal line. Metathorax with pair of small irregular shaped sclerites. Legs five-segmented, long, visible in dorsal view. Prothorax and mesothorax covered with small, scattered, dark patches.

Abdomen. First segment subdivided into two transverse folds, with a dorsal pair of narrow sclerites near anterior edge; segments 2 to 7 subdivided into four or five transverse folds, without sclerites. Segments 1 to 7 each with eight setose tubercles, four dorsal and two on each lateral margin; pleura weakly lobed. Segment 8 with a small, suboval, dorsal sclerite, posterior apex subdivided into four lobes and a pair of small procerci. Segment 9 round, with three small dorsal sclerites, bearing a pair of short, one-segmented urogomphi, and a pair of long paracerci; a pair of gill-like appendages (prostyli) originate on ventral side. Integument sparsely covered with relatively long setae. Single, narrow, darker line along midline of dorsal surface.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Identification

Agreement with generic description by Archangelsky (1997). Specimens were taken in association with *H. bovilli* Blackburn and are almost certainly that species.

Interspecific variation

There is little variation between the two known specimens.

Remarks

The larvae described above differ little from those of the New World *H. casta* (Archangelsky 1997; Spangler 1973) or the unidentified African species described by Berge Henegouwen (1982). The peculiar shape of the anterior mandibular tooth is diagnostic within the Australian fauna.

Specimens examined

Northern Territory: Holmes Jungle, 28/11/99.

Hydrophilus Geoffroy

Hydrophilus bilineatus (MacLeay). Fig. 12

Size of third instar. Length 35 mm; head capsule 3.25 mm long, 4.25 mm wide.

Head capsule. Suboval. Labroclypeus virtually symmetrical; nasale undeveloped; lateral lobes of epistome rounded, projecting farther than nasale. Frontal sulci broadly U-shaped, fusing just before reaching occipital foramen. Coronal sulcus present, very short. Gular sclerite absent. Cervical sclerites small, suboval.

Antennae. Four-segmented. First segment slender, slightly constricted near base, longer than remaining segments combined, with some slender setae on distal two-thirds of inner margin; second segment short, constricted near base in first instar larvae, third and fourth segments subequal in length. Sensory appendage on third segment reduced to a small papilla.

Mandibles. Asymmetrical; right mandible longer, more slender, with a large tooth on basal half which is divided by a longitudinal groove into ventral and dorsal sections; left mandible shorter, with one small inner tooth on basal half.

Maxillae. Five-segmented. Stipes narrow, elongate, longer than remaining segments combined, with three stout setae on inner margin. Palpus four-segmented; first segment the longest, with a short inner process; second and third segments subequal in length; fourth segment slightly shorter.

Labium. Mentum subrectangular, sides convex, anterolateral angles lobed, central third with some small spines (without spines in first and second instars). Prementum subtrapezoidal, anterior end wider with a pair of small protuberances towards front. Palpus two-segmented, first segment shortest. Ligula present, much shorter than first palpal segment.

Thorax and legs. Prothorax with two large sclerites together covering most of dorsal surface, the triangular area anterior to these sclerites usually sclerotised; ventral surface with a large subrectangular sclerite, with sagittal line. Mesothorax with a pair of subtriangular dorsal sclerites. Metathorax with a pair of narrow, basal

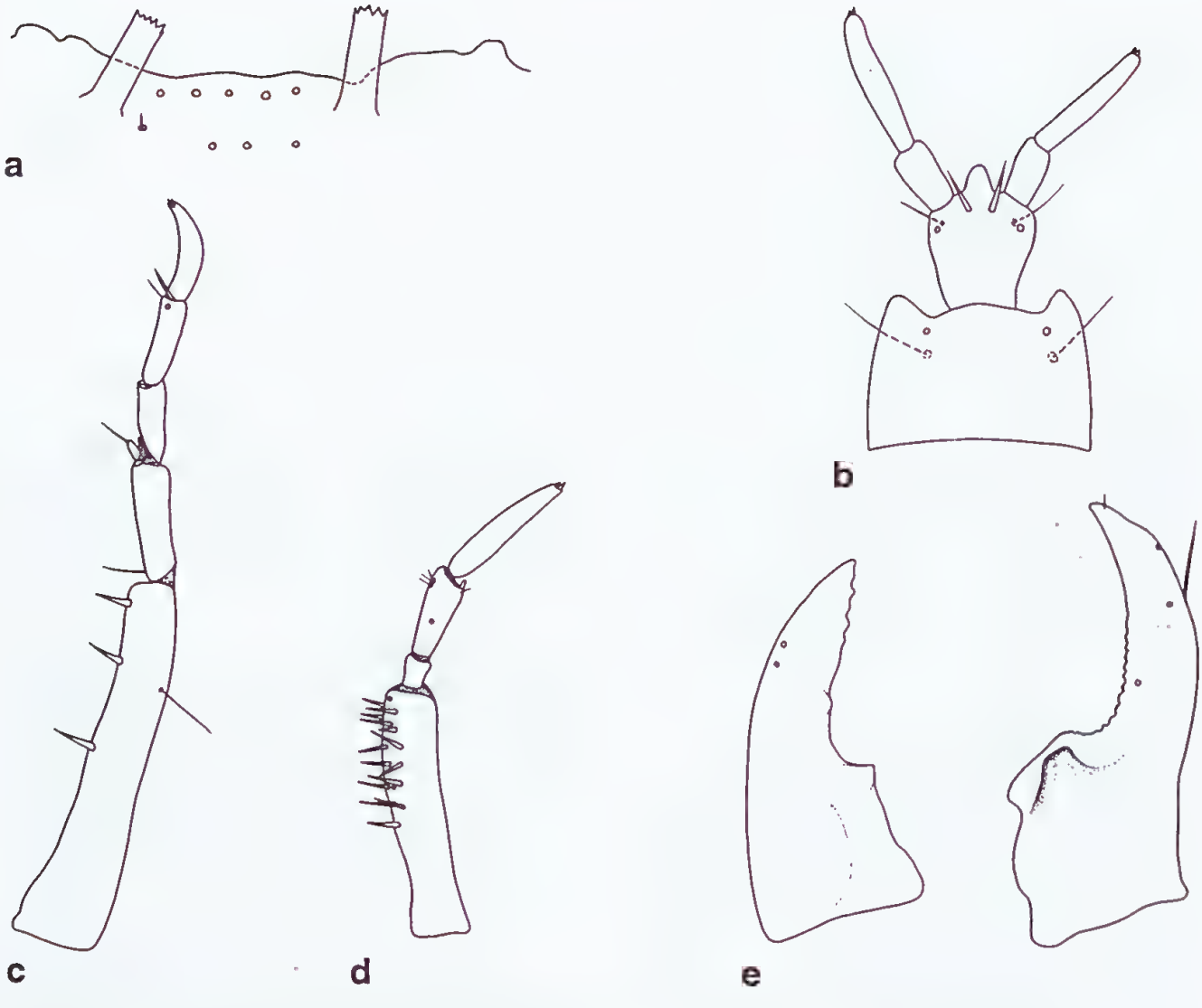


FIGURE 12. *Hydrophilus bilineatus*. **a**, labroclypeus; **b**, labium; **c**, maxilla; **d**, antenna; **e**, mandibles.

sclerites and a more central pair of small irregularly-shaped ones. Legs five-segmented, relatively short, visible in dorsal view, with rows of long swimming setae on both dorsal and ventral edges of femur and tibiotarsus.

Abdomen. Segments 1 to 6 similar in shape, tapering towards the caudal end; segments 7 to 8 more elongate and slender. Segments 1 to 7 subdivided into three transverse folds; third fold with two lateral and two dorsal small tubercles, more obvious on posterior segments. Pleura 1 to 8 each with a small lateral tubercle. Segment 8 with two small subtriangular sclerites at posterior end; segment 9 slightly trilobed, with a pair of short one-segmented urogomphi, ventromedially with a pair of long gill-like appendages. Integument in first instar very densely covered with small thin setae; in second and third instars moderately covered with thin, relatively long setae and numerous small 'bumps'.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles very small, non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Identification

By association and elimination.

Intraspecific variation

I have not noticed any significant variation within the few available specimens I have identified as *H. bilineatus*.

Interspecific variation

Within the larvae available there is considerable

variation in a number of characters, most notably: number of antennal segments vary from three to four; the presence/absence/form of the lateral projections on the abdominal segments; form of covering of the integument; dorsal colour pattern.

Remarks

The larvae of two European species, *H. piceus* Linnaeus and *H. aterrimus* Eschscholtz, and the North American *H. triangularis* (Say) are well known (Archangelsky 1997; Boving & Henriksen 1938; Richmond 1920). In addition, the larvae of *H. senegalensis* (Percheron) (Berge Henegouwen 1982; Africa) and *H. acuminatus* Motschulsky (Morioka 1955; Japan) have been described. Within the known larvae there is considerable variation in the number of antennal segments in different instars, in the development of lateral abdominal flaps and, at least within the Australian species, in the form of the integument coverage. Somewhat unusually for Hydrophilidae larvae, it appears that specific differences are sufficient to enable the larvae of many species to be identified.

In the lack of lateral abdominal flaps and its four segmented antennae, *H. bilineatus* most closely resembles the North American *H. triangularis* but differs in a number of details, most obviously in the more robust mandibles with a well-developed molar region. The other Australian species appear more distant, particularly in the well-developed abdominal flaps and number of antennal segments. With the more robust mandibles and abdominal flaps these Australian species appear to be closer to the subgenus *Diblocelus* (sensu Hansen 1991) than subgenus *Hydrophilus* (Archangelsky 1997). On adult characters they fit clearly into the subgenus *Hydrophilus*.

Egg cases of several species were collected in the field and each produced between 15 and 30 larvae. Those thought to be of *H. bilineatus* refused all food offered but the other species accepted, often with some excitement, small snails and some accepted freshly killed mosquito larvae. None accepted chironomid larvae. Unfortunately, despite seemingly accepting snails as food, none was reared to the second instar. Species varied in the degree of cannibalism. Some broods were quite strongly cannibalistic but in others, apart from the occasional unfortunate individual, siblings lived well together.

Specimens of *Hydrophilus bilineatus* (MacLeay) have previously been identified as *H. picicornis* Chevrolat (Hansen 1999).

Specimens examined

Northern Territory: Manton Dam, 23/3/97; 2 km S Adelaide River 1/2/99.

Hydrophilus sp. **Northern Territory**: Newry Station, 2/86 col. M. J. Tyler. **Queensland**: 25 km S Townsville, 3/5/98, 2/2/97; 8 km S Greenvale, 27/3/96; 5 km NE Mt Molloy, 30/3/96. **South Australia**: 10 km N Coonawarra, 10/11/97, 16/10/97; 1 km S Nangwarry, 9/10/97. **Tasmania**: 12 km N Hobart, 2/12/00; 2 km W Fingle, 23/1/00; 3 km SW Clifton Beach, 4/12/00. **Victoria**: 5 km NE Dartmoor, 11/10/97. **Western Australia**: Murchison River, 13/3/95, col. S. Halse; 6 km S Pinjarrah, 23/10/96.

Laccobius Erichson

Laccobius decipiens Gentili. Fig. 13

Size of third instar. Length 5.0–6.5 mm; head capsule 0.43–0.50 mm long, 0.45–0.46 mm wide.

Head capsule. Subrectangular. Labroclypeus strongly asymmetrical; nasale prominent, with three teeth; lateral lobes of epistome asymmetrical, both projecting further than nasale; left lobe larger, covering basal third of mandible, with a row of about 12 strong curved setae on inner margin, larger ones dentate; right lobe smaller, covering a quarter of mandible, without setae. Frontal sulci parallel, reaching occipital foramen without coming together, difficult to see in third instar larvae. Coronal sulcus absent. Gular sclerite absent; cervical sclerites small and oval, difficult to see in first instar larva.

Antenna. Three-segmented; second segment the longest, with a small outer sensory appendage about a quarter the length of third segment; first segment half the length (first instar larvae) to slightly shorter (third instar larvae) than second segment.

Mandibles. Strongly asymmetrical. Left mandible with three inner teeth, central one largest, with five strong spines, region behind third tooth with a number of very short spines; right mandible with two inner teeth, larger than those of left mandible, front one much larger, occasionally also with a very small third tooth, or spine, behind the second.

Maxillae. Five-segmented. Stipes wide, longer than remaining segments combined, inner margin with four setae. Palpus four-segmented; first segment subquadrate, incompletely sclerotised, with a small inner process; second segment shortest; third and fourth segments subequal in length.

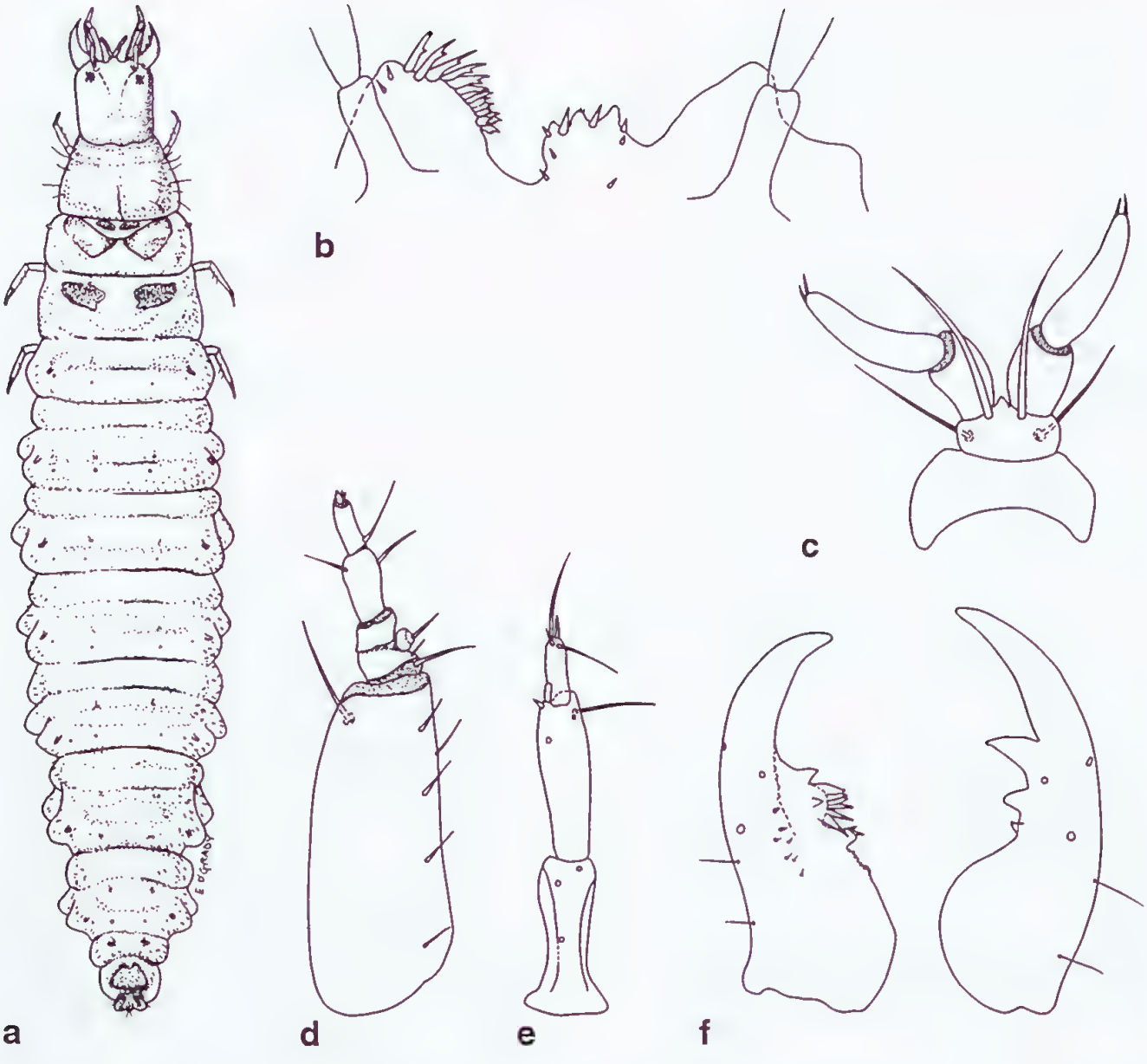


FIGURE 13. *Laccobius decipiens.* **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, maxilla; **e**, antenna; **f**, mandibles.

Labium. Mentum small and narrow, subrectangular. Prementum slightly larger, trapezoidal. Palpus two-segmented, first segment shorter, second segment two to three times longer than first. Ligula obsolete, at most reduced to a slight bulge.

Thorax and legs. Prothorax completely covered by a large dorsal sclerite, with sagittal line; ventrally with a pair of large subrectangular sclerites, fused in anterior half. Mesothorax with two pairs of dorsal sclerites, anterior one small, subrectangular; posterior pair larger, subtriangular. Metathorax with one pair of small, irregularly shaped sclerites intermediate in size to the two mesothoracic ones. Legs five-segmented, visible in dorsal view.

Abdomen. Segments 1 to 7 similar in shape, tapering towards posterior end, segments subdivided by transverse folds; sides with several slight bulges, each segment with a pair of long dorsal setae arising from small, darkly pigmented areas, one just behind spiracle and the other near midline. Segment 8 with a subtriangular dorsal sclerite. Segment 9 small, trilobed, bearing a pair of small one-segmented urogomphi. Integument with quite dense covering of short fine setae.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles non-functional, on short dark-pigmented papillae; spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Intraspecific variation

Within specimens that I have identified as this species there is some variation as follows: some specimens have an additional small third tooth on the right mandible; in newly moulted specimens there are slight serrations on the upper mandibular teeth which appear to wear away quickly; the first abdominal segment occasionally has a pair of very small dorsal sclerites.

Interspecific variation

Within specimens unidentified to species there is variation in the shape of the dorsal sclerites on abdominal segment 8; the width of the nasale and the shape of the nasale teeth; the presence, size and position of abdominal sclerites. Overall these differences are slight.

Identification

By rearing larvae collected in the field.

Specimens examined

New South Wales: Bombala, 28/11/98; ditto, 4/11/97; ditto, 18/1/97. **Victoria**: Stratford, 7/11/97.

Laccobius spp. **Queensland**: Kauri Creek near Tinarro Dam, 24/10/93, col. D. Larson.

Remarks

There is little difference between the larvae of the Australian species and those of the North American *L. minutoides* Orchymont and *L. agilis* (Randall) described and illustrated by Richmond (1920) and Archangelsky (1997).

Limnoxenus Motschulsky

Limnoxenus zealandicus (Broun). Fig. 14

Size of third instar. Length 11.5–15.0 mm; head capsule 1.60–1.79 mm long, 1.62–2.00 mm wide.

Head capsule. Square. Labroclypeus slightly asymmetrical; nasale moderately developed, angled slightly with right side more forward, with five teeth, left tooth a little distant from others; lateral lobes of epistome rounded, projecting not quite as far as nasale, right lobe often a little more rounded and a little more projected than left lobe. Frontal sulci U to V-shaped, fusing just before reaching occipital foramen. Coronal sulcus very short. Gular sclerite absent. Cervical sclerites relatively small, subrectangular.

Antennae. Three-segmented. First segment longer than remaining segments combined, with some slender setae on distal two-thirds of inner margin; second segment about twice the length of third segment which is very thin. Sensory appendage on second segment minute.

Mandibles. Symmetrical with three inner teeth, progressively smaller towards base.

Maxillae. Five-segmented. Stipes stout, longer than remaining segments combined, with four long stout setae on inner margin. Palpus four-segmented; first segment the widest, with a short inner process; second and fourth segments short, subequal in length; third segment longest.

Labium. Mentum subrectangular, sides slightly concave, dorsal surface with small spines, anterolateral angles rounded, with several stout spines. Prementum square, not much smaller than mentum. Palpus two-segmented, first segment the shortest. Ligula present, slightly longer than first palpal segment, tip bifid.

Thorax and legs. Prothorax with large dorsal sclerite, with sagittal line; ventral surface with a large subrectangular sclerite, with sagittal line. Mesothorax with a pair of large triangular dorsal sclerites. Metathorax with a pair of wineglass-shaped dorsal sclerites sometimes with stem of wineglass absent. Rest of surface of thorax covered with very short spines, occasionally arranged in short rows. Legs five-segmented, relatively short, barely visible in dorsal view.

Abdomen. First segment with a dorsal pair of small subovoid sclerites close to anterior margin. Segments 1 to 6 similar in shape, tapering towards the caudal end; segments 7 and 8 more elongate and slender. Segments 1 to 7 subdivided into three transverse folds; dorsal surface of third fold with four small, dark, narrowly cylindrical tubercles; sides of each segment with three slight, fleshy bulges. Segment 8 with a large suboval dorsal sclerite, with three to four quite deep indentations on hind edge, lighter coloured towards middle. Segment 9 trilobed, with a pair of short one-segmented urogomphi. Integument densely covered with small setae and a sparse covering of longer setae which get progressively smaller posteriorly. Dorsal surface often with two darker stripes through sclerites and inner pair of tubercles.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles non-functional, on small papillae. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Intraspecific variation

The number of nasale teeth is variable with up

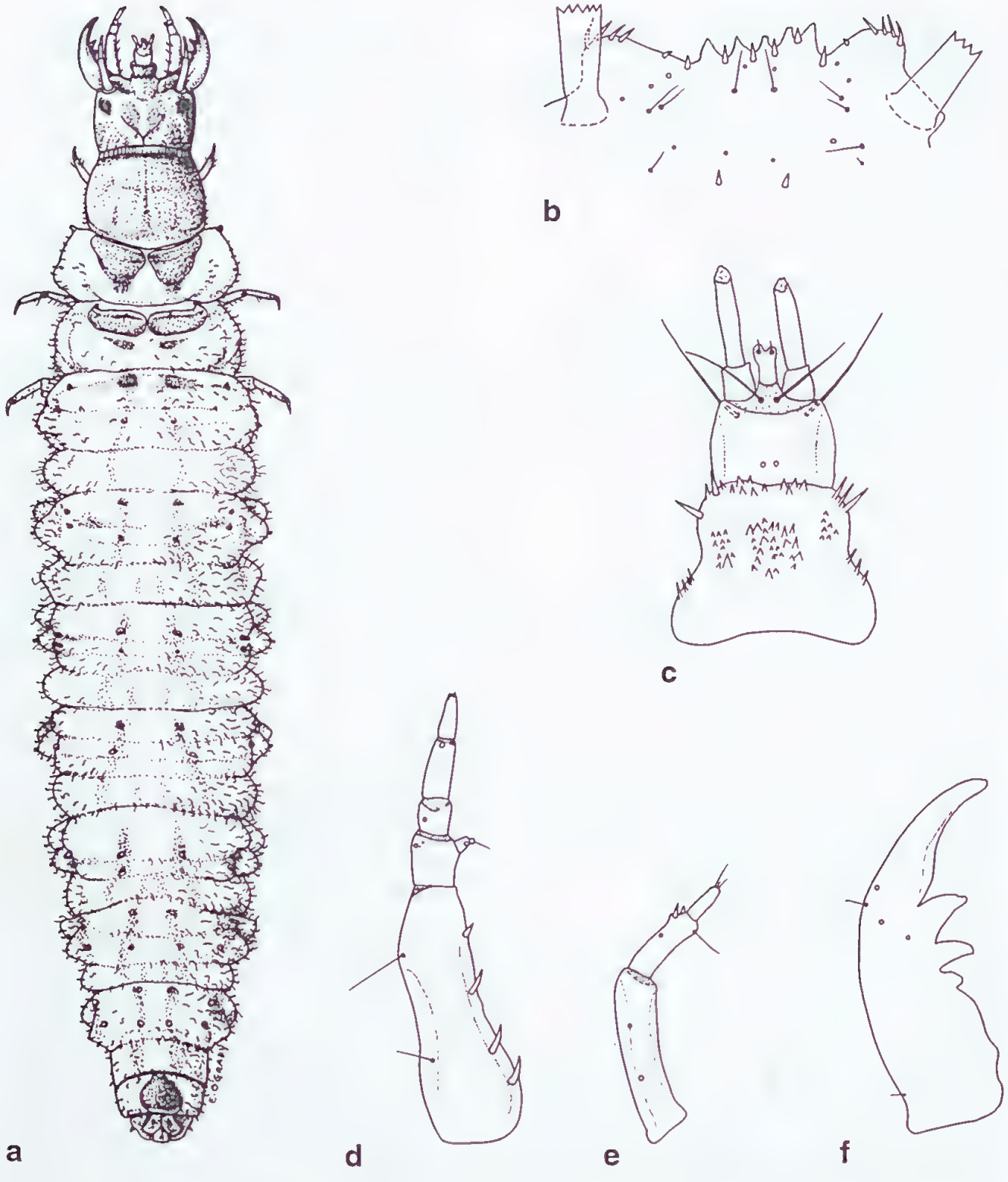


FIGURE 14. *Limnoxenus zealandicus*. **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, maxilla; **e**, antenna; **f**, mandible.

to ten smaller teeth in some specimens; in some specimens these are worn down to the stage where the front of the nasale is almost smooth. The central nasale teeth are not well developed in first instar larvae. In one specimen the antennae are four segmented with the normal third segments clearly divided into two. ....

Identification

By rearing from larvae collected in the field.

Remarks

The larva of the European *L. niger* (Gimelin) has already been described by Berge Henegouwen (1975). The larva of the sole Australian and New

Zealand species differs little from those of this species.

One of the most commonly collected hydrophilid larvae in Australia, it is quickly recognised by the parallel darker stripes on the dorsal surface and combination of relatively short basal segment to the antenna and symmetrical three-toothed mandibles. The dense covering of small setae gives the abdomen a fur-like look.

Specimens examined

New South Wales: 10 km E Braidwood, 30/11/95; Braidwood, 19/1/97.

South Australia: 10 km N Coonawarra, 10/11/97; 10 km E Mt Compass, 13/9/97; Mt Crawford Forest, 10/11/96; 6 km N Forreston, 3/10/95; 19 km N Forreston, 3/9/99; 1 km S Nangwarry, 9/10/97; ditto, 29/8/99; 2 km S Penola, 20/11/99; Warburton River, 2–8/10/99, 27°52'23"S 137°54'40"E; Watervalley, 7.2 km NNE Mt Rough, 15/10/00. **Tasmania**: Lake St Clair, 4 km N Derwent Bridge, 25/1/00. **Victoria**: 5 km NE Dartmoor, 11/10/97; 2 km W Brimpaen, 23/9/98; Healsville, 12/68; 6 km N Noojee, 16/1/97. **Western Australia**: Gin Gin, 15/10/96; 10 km E Kalamunda, 16/10/96; 2 km W Nannup, 20/10/96; 6 km S Pinjarrah, 23/10/96; 1 km S Serpentine, 24/10/96; 10 km S Yallingup, 22/10/96.

Regimbartia Zaitzev

Regimbartia attenuata (Fabricius). Fig. 15

Size of third instar. Length 5.0–7.5 mm; head capsule 1.00–1.01 mm wide, 0.75–0.80 mm long.

Head capsule. Subquadrangular. Labroclypeus symmetrical; nasale very short, with numerous short teeth on anterior border of epistome; lateral lobes of epistome rounded, very short, not projecting as far as nasale, each with two long setae. Frontal sulci straight, short, meeting at about the level of the antennal bases. Coronal sulcus long, about half the length of the head capsule. Gular sclerite absent. Cervical sclerites small, subrectangular.

Antennae. Three-segmented. First segment slender, longer than other two combined, with a prominent subapical inner process some distance from apex. Sensory appendage on second segment slim, slightly shorter than third antennal segment.

Mandibles. Virtually symmetrical, long and slender, with two inner teeth on basal half; distal tooth large, basal one small.

Maxillae. Five-segmented. Stipes slender, much longer than remaining segments combined, with four or five setae on inner margin. Palpus four-segmented; third segment longest; second segment shortest; first and fourth segments subequal in length, first segment with a short inner process.

Labium. Mentum large, wider than long, sides convex, dorsal surface with cuticular spines. Prementum elongate, much narrower than mentum. Palpus two-segmented, basal segment short. Ligula annular, two to three times as long as basal segment of palpus.

Thorax and legs. Prothorax with a large dorsal sclerite, with sagittal line; surface covered by minute spines; fringe of long, slender setae around the margins, four small spines, one on each anterolateral angle and two towards the middle; ventral surface with large, subrectangular sclerite, without sagittal line. Mesothorax with two dorsal pairs of subtriangular sclerites; metathorax with one dorsal pair of irregular shaped sclerites. Both mesothorax and metathorax with five pairs of setiferous projections, about half of them with a narrow cylindrical projection with a long seta attached at the end. Legs five-segmented, long, visible from above.

Abdomen. Segments 1 to 7 with five pairs of setiferous projections similar to those on thorax, four lateral ones with one more posterior than others and one closer to midline. In addition, the abdomen is covered with small stellate setae and the dorsal surface with small projections each with six to eight long, sharply pointed setae (in most specimens these structures are obscured by an accumulation of sand grains and detritus). Segment 8 without setiferous projections, with a pair of small finger-like 'procerci', with dorsal semispherical sclerite which covers the spiracular atrium. Segment 9 trilobed, with a pair of small, unsegmented urogomphi.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Interspecific variation

There is little variation between the few specimens seen.

Identification

By association of adults and larvae by isoenzyme electrophoresis.

Remarks

The larvae closely resemble both *Allocotocerus*

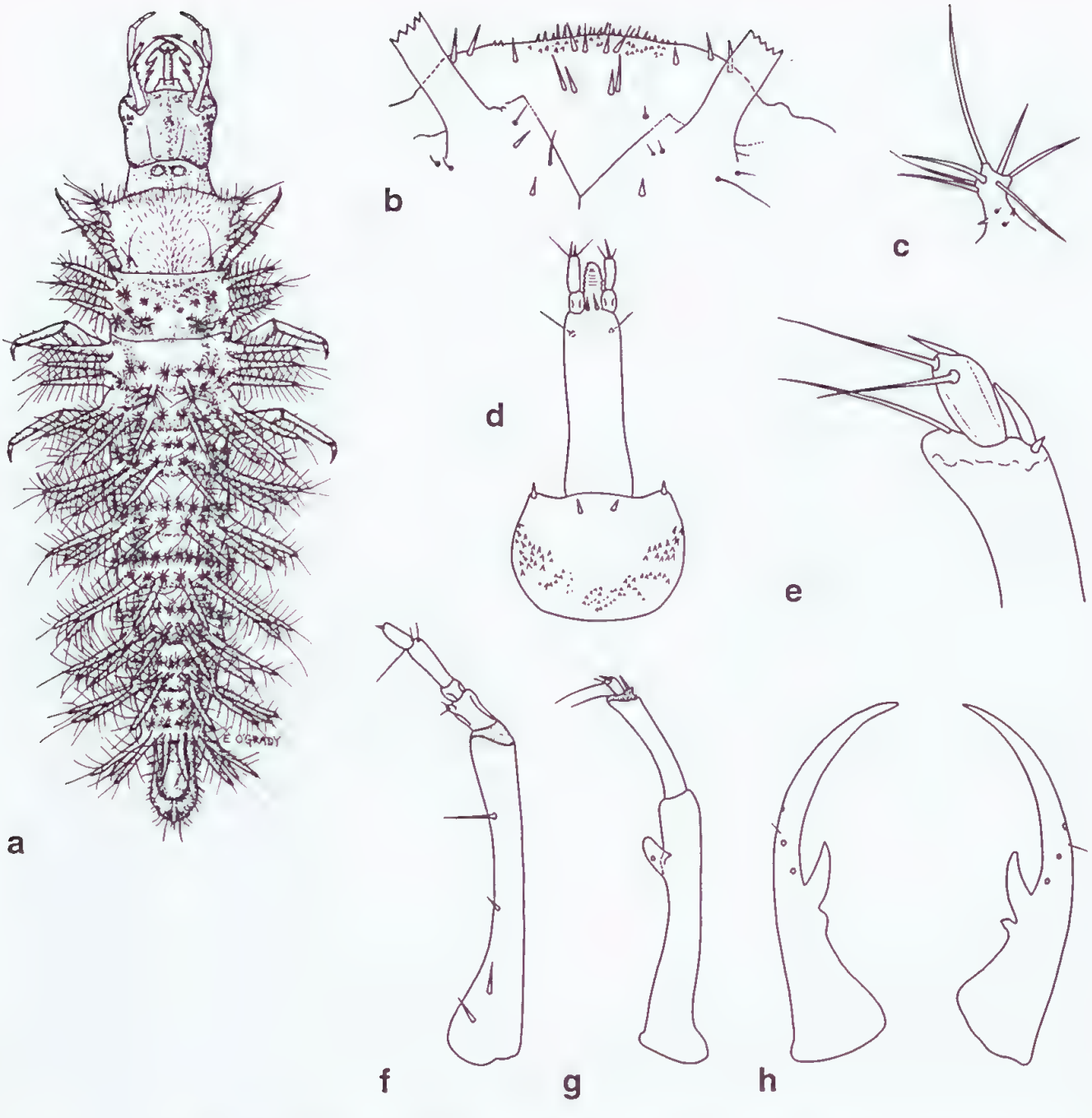


FIGURE 15. *Regimbartia attenuata.* **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, detail of abdominal stella; **e**, tip of antenna; **f**, maxilla; **g**, antenna; **h**, mandibles.

and the New World *Derallus* (Archangelsky 1997; Spangler 1966), all three genera showing a suite of unusual characters that clearly separate them from other Hydrophilid larvae. The differences between the genera are relatively slight (see key and under *Allocotocerus*).

Specimens examined

Queensland: 6 km N Bluewater, 3/2/97; 15 km W Mareeba, 6/12/90, col. D. Larson; 5 km NW Mareeba, 22/9/90, col. D. Larson; 2 km N Mt Molloy, 1/4/96.

Sternolophus Solier

Sternolophus marginicollis (Hope). Fig. 16

Size of third instar. Length 11.5–15.0 mm; head capsule 1.80–1.90 mm long, 1.55–1.70 mm wide.

Head capsule. Subrectangular. Labroclypeus weakly asymmetrical; nasale short, weakly projecting with five short teeth, left one a little distant from rest; lateral lobes of epistome symmetrical not projecting beyond nasale, undulating. Frontal sulci V-shaped, fusing before

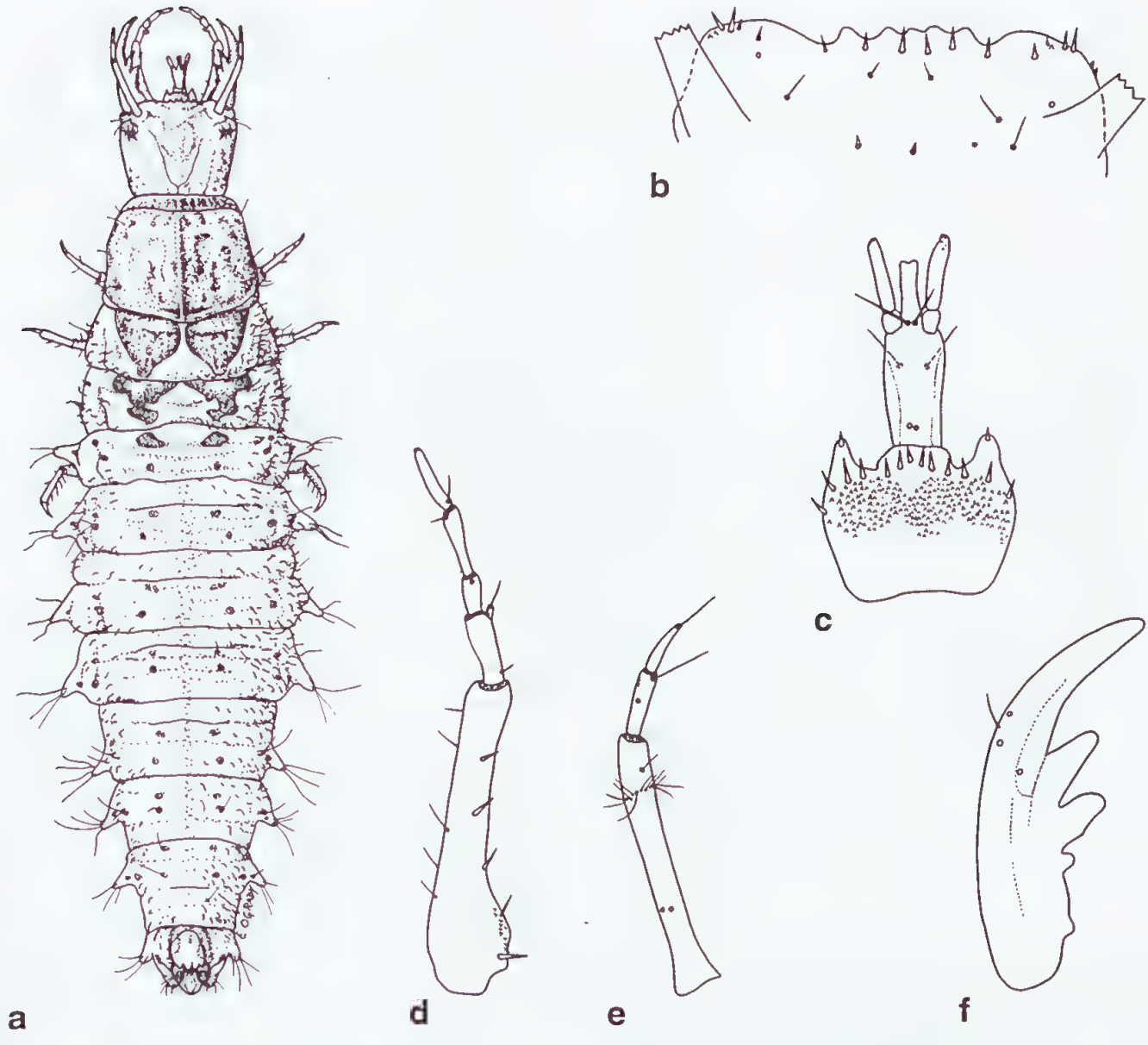


FIGURE 16. *Sternolophus* sp. **a**, habitus; **b**, labroclypeus; **c**, labium; **d**, maxilla; **e**, antenna; **f**, mandible.

reaching occipital foramen. Coronal sulcus short. Gular sclerite absent. Cervical sclerites small, suboval, longitudinally oriented. Frontal sulcus outlined in a darker colour.

Antennae. Three-segmented. First segment much longer than other two combined, with an annular ring of long setae near apex in second and third instars; second segment and third segment subequal. External apical appendage on second segment lacking; a small flat button-like structure on outside towards apex.

Mandibles. Virtually symmetrical, with three inner teeth, distal two large, basal one much smaller.

Maxillae. Five-segmented. Stipes as long (first instars) or longer (second and third instars) than remaining segments combined, with four or five setae on inner margin and patch of small spines on inside near base. Palpus four-segmented; first segment with an inner apical process; second segment short; third and fourth segments a little shorter than first.

Labium. Mentum with sides convex, slightly wider than long, anterolateral corners pointed, dorsal surface with numerous small cuticular spines and row of longer spines towards apex; small spines mostly absent in first instar. Prementum long and thin. Palpus two-segmented, basal segment much shorter than distal. Ligula a little shorter than distal segment of palpus, slightly bifid at tip.

Thorax and legs. Prothorax with large dorsal

sclerite, with sagittal line, with pattern of darker lines and dots; ventral surface with a large subrectangular sclerite, with sagittal line. Mesothorax and metathorax each with a dorsal pair of subtriangular sclerites, smaller than those of prothorax. Legs five-segmented, long, visible in dorsal view, with rows of long swimming-setae on femur and tibiotarsus.

Abdomen. Segments 1 to 6 similar in shape, tapering towards the caudal end; segments 7 and 8

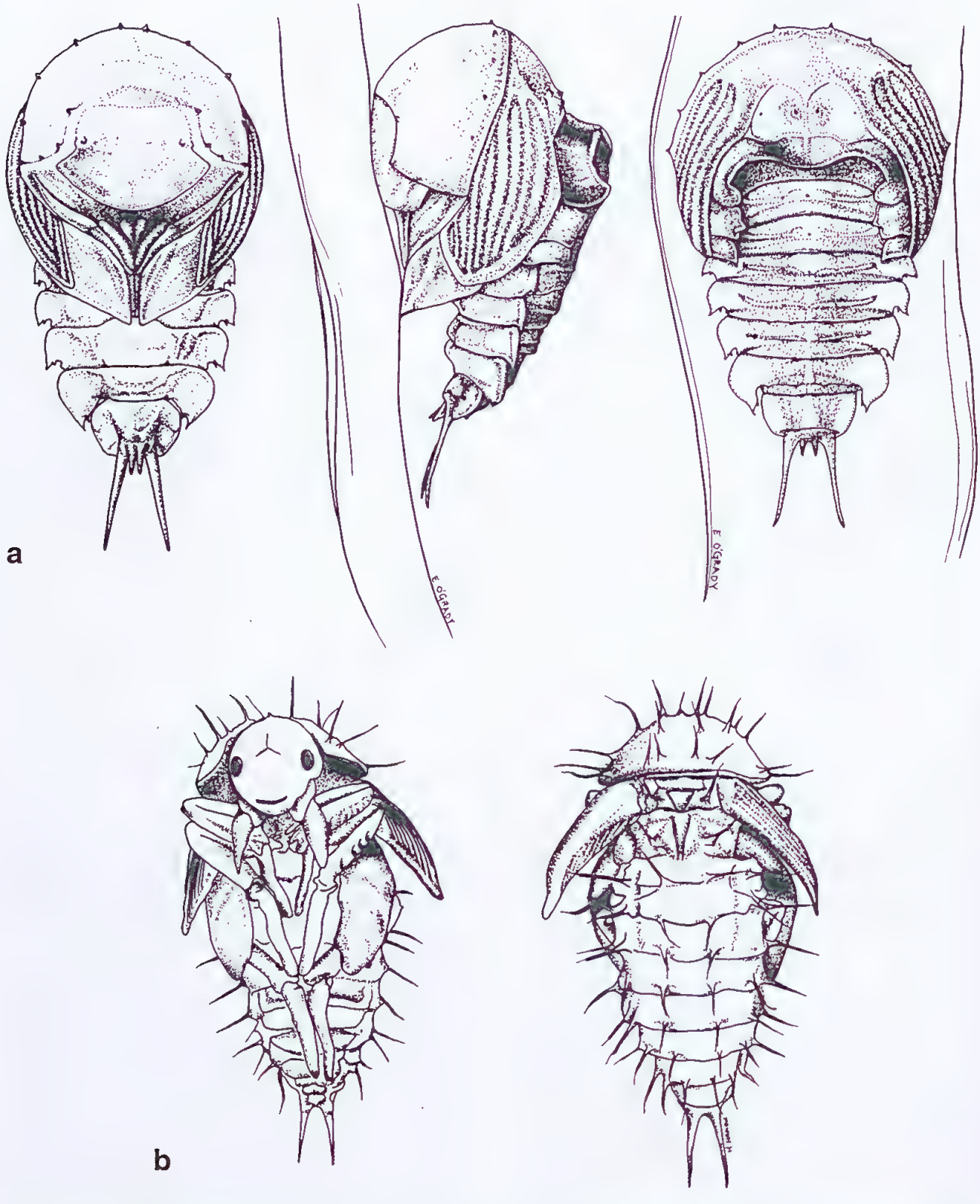


FIGURE 17. **a**, *Amphiops queenslandicus*: ventral, lateral and dorsal views of pupa. **b**, *Hybogralius hartmeyeri*: ventral and dorsal views of pupa.

more elongate and slender. Segments 1 to 7 subdivided into three transverse folds, each segment with transverse row of six pairs of long setae arising from short dark-pigmented cylindrical bases on dorsal surface of posterior fold. Pleura 1 to 8 each with a small, lateral, setiferous tubercle. Segment 8 with two small, dorsal, subtriangular sclerites at posterior end. Segment 9 slightly trilobed, with a pair of short one-segmented urogomphi. Integument densely covered with both very short and moderately long setae.

Spiracles. Nine pairs; one mesothoracic and eight abdominal. Mesothoracic and first seven abdominal spiracles non-functional. Spiracles on segment 8 annular, large and functional, within the spiracular atrium.

Intraspecific variation

There is some suggestion of two longitudinal dark lines on the dorsal surface in some specimens, and in an occasional specimen the small third mandibular tooth is virtually absent.

Interspecific variation

In some specimens of *Sternolophus* there is a greater development of the lateral abdominal tubercles into quite prominent finger-like projections, especially towards the rear; a row of setiferous papillae across the abdominal segments instead of small cylinder-like structures; a more symmetrical nasale; a stronger third mandibular tooth; and some difference in the shape of the meso and metathoracic sclerites (the habitus drawing (Fig. 16) is of this form). These larvae are *S. centralis* Watts and/or *S. immarginatus* Orchymont. The distribution of specimens would suggest the latter but not certainly so.

Identification

By rearing from field-collected larvae.

Remarks

The larva of *S. marginicollis* is one of the few Australian larvae already known (Bertrand 1935) as *S. tenebricosus* Blackburn, a junior synonym (Watts 1989), although the identification was by association, which is unsafe in this genus because it often has two or more species common at the same locality. Other species have been described from Africa and Japan (see Bertrand 1972). The present larvae, certainly of *S. marginicollis* and probably also including *S. immarginatus* Orchymont, do not differ significantly from the published descriptions and illustrations.

Larvae of *Sternolophus* are commonly encountered in Northern Australia and can be readily separated from other Hydrophilid larvae by the combination of long thin prementum, long ligula and mandibles with three teeth.

Specimens examined

Northern Territory: Jabiru, 19/3/98; Manton Dam, 2/2/99; Ormiston Gorge, 27/1/99. **Queensland**: Killymoon Creek, 25 km S Townsville, 2/2/97.

Sternolophus sp. **Northern Territory**: Holmes Jungle near Darwin, 28/1/99. **Queensland**: 8 km N Bluewater, 31/10/95; Bohle River, 10 km N Townsville, 23/3/96; Eubenangee Swamp, 4/2/97; 2 km S Mt Molloy, 30/3/96.

Acknowledgments

I wish to thank Mr Rod Gutteridge, Ms Eloese O'Grady and Mr Harold Hamer for so ably preparing the illustrations; Dr David Larson for donating larvae he collected whilst working in North Queensland; the South Australian Library staff, Ms Marianne Anthony and Ms Jill Evans, for procuring references that we did not already have in the library; and Ms Debbie Churches for preparing the final manuscript copy. I would particularly like to thank Dr Steve Donnellan of the Evolutionary Biology Unit of the South Australian Museum for undertaking the biochemical matching of adult and larval *Allocotocerus* and *Regimbartia*.

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EMBOLOCEPHALUS YAMAGUCHII (BRINKHURST, 1971) (CLITELLATA: TUBIFICIDAE) FROM SOUTH AUSTRALIAN STREAMS

AM PINDER & PK McEVOY

PINDER, AM & McEVOY, PK. 2002 *Embolocephalus yamaguchii* (Brinkhurst, 1971) (Clitellata: Tubificidae) from South Australian streams. *Records of the South Australian Museum* 35(2): 139–145.

Papillate tubificids from streams in the Mount Lofty Ranges are identified as *Embolocephalus yamaguchii* (Brinkhurst, 1971) and represent the first records of this largely Holarctic genus from Australia. Collection details are provided for records of a second papillate species, identified as belonging to the genus *Spirosperma*.

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Most tubificids with papillate body walls are contained within a complex of genera (including *Embolocephalus* Randolph and *Spirosperma* Eisen) established, or re-established, following revision of the genus *Peloscolex* Leidy (Brinkhurst 1991; Brinkhurst & Wetzel 1984; Holmquist 1978, 1979). These genera have a largely Holarctic distribution, with few records from southern continents. The latter consist of a record of the otherwise European *Embolocephalus velutinus* (Grube, 1879) from Venezuela (Dumnicka, 1983), an identification questioned by Brinkhurst and Marchese (1989), and papillate tubificids of uncertain identity from Peru (Brinkhurst & Marchese 1989). The North American species *Quistadrilus multisetosus* has been recorded as far south as Mexico. In Australia, Timms (1978) recorded *Peloscoiex* (*sic*) from a lake in Tasmania and Pinder & Brinkhurst (1994, 2000) noted papillate tubificids from Victoria and New South Wales. The latter were all immature so descriptions were not possible, but they were tentatively assigned to *Spirosperma*, based on the presence of papillae and the form of the chaetae. Collection details for this species, including the first records from South Australia, are presented below for the first time. Other specimens, collected from streams in the Mount Lofty Ranges in South Australia, are herein described and identified as *Embolocephalus yamaguchii* (Brinkhurst, 1971), a species otherwise known only from Lake Biwa in Japan.

Methods

Serially sectioned specimens were cut at 6 µm and stained in haematoxylin and eosin. Measurements were taken using an eyepiece graticule on a Zeiss Jenamed 2 compound microscope calibrated with an Olympus stage micrometer. Abbreviations used in the line-drawings are a: atrium, cp: cuticular pad, e: large epidermal papillae, ed: ejaculatory duct, ff: female funnel, mf: male funnel, p; prostate, pe: penis, sa: spermathecal ampulla, sc: spermathecal chaeta, scg: spermathecal chaetal gland, v: vas deferens. Specimens are either in the senior author's collection (AP) or the Australian Water Quality Centre collection (AWQC); returned to WSL Consultants (WSL) or Australian Water Technologies (AWT); or deposited with the South Australian Museum (SAM) or the Museum of Victoria (NMV).

Systematics

Embolocephalus Randolph, 1892

Type species

Embolocephalus velutinus (Grube, 1879)

Diagnosis

From Holmquist (1978) and Brinkhurst (1981). Prostomium and sometimes first segments retractable within the rest of body. Body wall with epidermal papillae, generally concealed by a

secreted layer with embedded foreign particles. Hair chaetae present dorsally, usually broad and sabre-like, with pectinate crotchet chaetae. Bifid and/or simple pointed chaetae present ventrally, usually both in anterior bundles. Spermathecal chaetae modified on X, lying in a well-developed chaetal sac. Male ducts each with a long winding vas deferens, usually narrower entally and broader (up to twice the width) ectally, entering the atria apically. Atria long and tubular to crescentic, broadest near the prostate union, tapering to a short ejaculatory duct. One large prostate gland joining each atrium towards the middle of the latter. Penes well developed without thickened cuticular sheaths. Spermathecae with ovoid to oblong ampullae, well set off from the ducts, with pores usually more or less in front of and lateral to the spermathecal chaetal sacs.

Distribution

Europe, North America, Japan, Kamchatka, ?Venezuela and now Australia.

Embolocephalus yamaguchii (Brinkhurst, 1971)

Peloscolex yamaguchii Brinkhurst, 1971: 505

Peloscolex sp. Yamaguchi, 1953: 295

Embolocephalus yamaguchii (Brinkhurst, 1971) Ohtaka, 1994: 52; 1995: 174

Material examined

South Australian specimens. SAM E3095–3101: 3 mature specimens serially sectioned, 3 mature dissected and 1 immature whole-mounted, Aldgate Creek at Strathalbyn Road, Mylor, tributary of the Onkaparinga River (AWQC site 3217), 35°02'S 138°45'E, samples E33, 3 June 1997 and F32, 27 Oct 1997. AP: 1 mature serially sectioned, collected as above. SAM E3102–3103: 1 mature in alcohol, Onkaparinga River at Houlgraves Weir (AWQC site 3205), 35°05'S 138°43'E, sample E37, 3 June 1997, and 1 mature whole-mounted from same site, sample F37, 28 Oct 1997. SAM E3104: 1 mature in alcohol, Aldgate Creek at Aldgate Valley Road (AWQC site 13022), 35°02'S 138°45'E, sample H41, 2 Dec 1998. AWQC: 5 immature in alcohol, Onkaparinga River at Hack Bridge (AWQC site 3212), 35°03'S 138°45'E, sample H43, 1 Dec 1998. AWQC: 1 immature in alcohol, Lenswood Creek at gauging station (AWQC site 3208), 34°56'S 138°50'E, sample OCB148, 17 Jul 2000: AWQC: 2 mature in alcohol, Onkaparinga River at Silver Lake Road (AWQC site 13023), 35°04'S 138°45'E, sample OCB181, 17 Oct 2000. Collections by V. Tsymbal, P. McEvoy, A. Lang and S. Wade (Australian Water Quality Centre, South Australia).

Japanese specimens. From collection of A. Ohtaka (Hirosaki University, Japan): 1 mature specimen serially sectioned, 1 mature whole-mounted and 2 mature in alcohol (now dissected), Lake Biwa, Japan.

Habitat

This species has been collected only from a sixth order reach of the Onkaparinga River upstream of Mount Bold Reservoir and from two fourth order tributaries, between 245 and 295 metres above sea level. Specimens were collected from both riffle and edge habitats, with substrates ranging from those composed mainly of bedrock, boulder or cobble to those dominated by finer sediments and/or detritus. Willow root mats are a common feature on the stream bed of most sites. Riparian zones had an overstorey of either indigenous *Eucalyptus* species and *Acacia melanoxylon* and/or introduced willows (*Salix* spp.). Land uses include grazing, horticulture and urban settlement. Apparently similar habitats in adjacent catchments were sampled with the same sampling intensity without finding *E. yamaguchii*.

Description of Australian specimens

Length of preserved specimens 15.6–25.5 mm, width at clitellum 0.7–1.1 mm. Each pre-clitellar segment with a band of tall, broad epidermal cells forming a raised transverse ridge in the middle of the segment, pronounced dorsally and laterally but virtually absent ventrally. Body surface with foreign material adhered to elongate ovoid papillae covering the entire body except for the clitellum (Fig. 1). Papillae mostly 15–22 µm long on pre-clitellar segments (measured on the longest axis, including foreign particles) and 20–34 µm long on post-clitellar segments, and mostly 17–25 µm high (with most of the height constituted by the foreign material). Ridges of anterior segments with fewer or no papillae. Each segment also with 2 rings of papillae that are taller and broader than normal (up to 40 µm wide and 40 µm high including foreign material), which give the appearance of darker (or sometimes lighter) bands around each segment, 1 ring about at the level of the chaetae and 1 anteriorly on each segment, most pronounced on posterior segments.

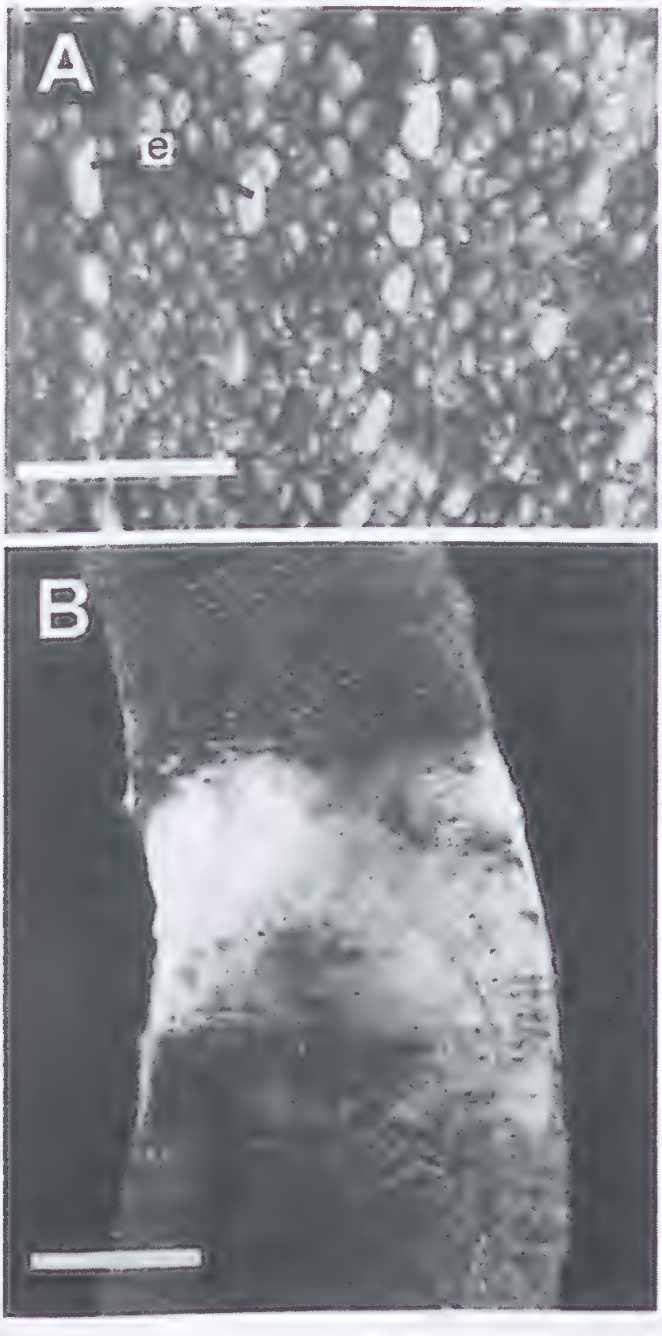

FIGURE 1. *E. yamaguchii* **A**, Enlarged view of body wall of segments towards the posterior end of SAM E3098 (prior to slide mounting) showing normally sized and enlarged (e) papillae; **B**, Portion of SAM E3104 showing lateral view of anterior segments (top), clitellum (centre) and post-clitellar segments (bottom). Scale bar for A 100 µm, B 500 µm.

Other (possibly sensory) papillae present with the foreign material adhered only to the sides, with the top of the papillae exposed, arranged in ill-defined rings around each segment (about 10 of these papillae per ring), usually 1 ring at the level of the chaetae and 1 or more rings between the chaetae and intersegmental furrow. These partially naked papillae are about the same size as the shorter type of fully encased papillae and are sometimes visible as darker or paler spots. A pad of tall, thin epidermal cells, with cuticle 10 times thicker (up to 17 µm) than elsewhere, present medially on the spermathecal segment, adjacent to the anterior spermathecal chaeta. Clitellum covering posterior half of X and all of XI, paler than other segments due to a smooth even coating of soft white granular material (Fig. 1).

Prostomium partially retracted into first segment in fixed animals. Pharynx with dorsal muscular pad in II to III, with pharyngeal gland cells on pharynx and on septa 3/4 to 4/5. Oesophagus from IV to VI, widening into broader thicker-walled intestine in VII.

Ventral chaetae 130–211 µm long and 7–14 µm wide at nodulus, generally smallest in pre-clitellar bundles. Ventral bundles on II to VIII usually with 1 bifid and 1 simple pointed chaeta, rarely 1 extra bifid chaeta and/or 1 or 2 extra simple pointed chaetae. Bifid chaetae with teeth equal in width but upper tooth up to 1.5 times longer than lower (Fig. 2B). Posterior ventral bundles with 1 (rarely 2) bifid chaetae, with upper teeth becoming shorter than lower and lower tooth greatly expanding in width and becoming notably recurved (Fig. 2C). Dorsal chaetal bundles normally with 2 to 4 slightly curved hair chaetae, 220–420 µm long and 4–7 µm wide, with finely plumose shafts and blunt, slightly swollen, tips, with an equivalent number of short (32–75 µm long and 1–2 µm wide) finely pectinate crotchets with thin parallel outer teeth (Figs 2D,E). Posterior dorsal bundles with fewer of both types of chaetae. Chaetae of spermathecal segment modified (Figs 2A, 3A,B), ventral chaetae absent in XI.

Genitalia paired (Figs 2, 3B). Testes anteroventral in X, ovaries anteroventral in XI. Male funnels large, ciliated vasa deferentia broad near funnels (35 µm), narrowing shortly thereafter (17–20 µm) and widening slightly ectally (25–33 µm), highly coiled, joining ental end of atria. Atria each with a narrow lumen and layer of tall glandular lining cells, crescentic, broadest where a single prostate gland joins (slightly entad of medial), tapering at either end, the ectal end forming a short ejaculatory duct which enters the penis apically. Atrial muscle layer thin, wider where prostate joins. Atrium, including ejaculatory duct, measuring 800 x 110 µm to 1000 x 185 µm. Prostate glands voluminous, sometimes ballooning into following segment. Penes broad entally, narrowing at about one-third of the distance from the tip to form a narrower ectal end,

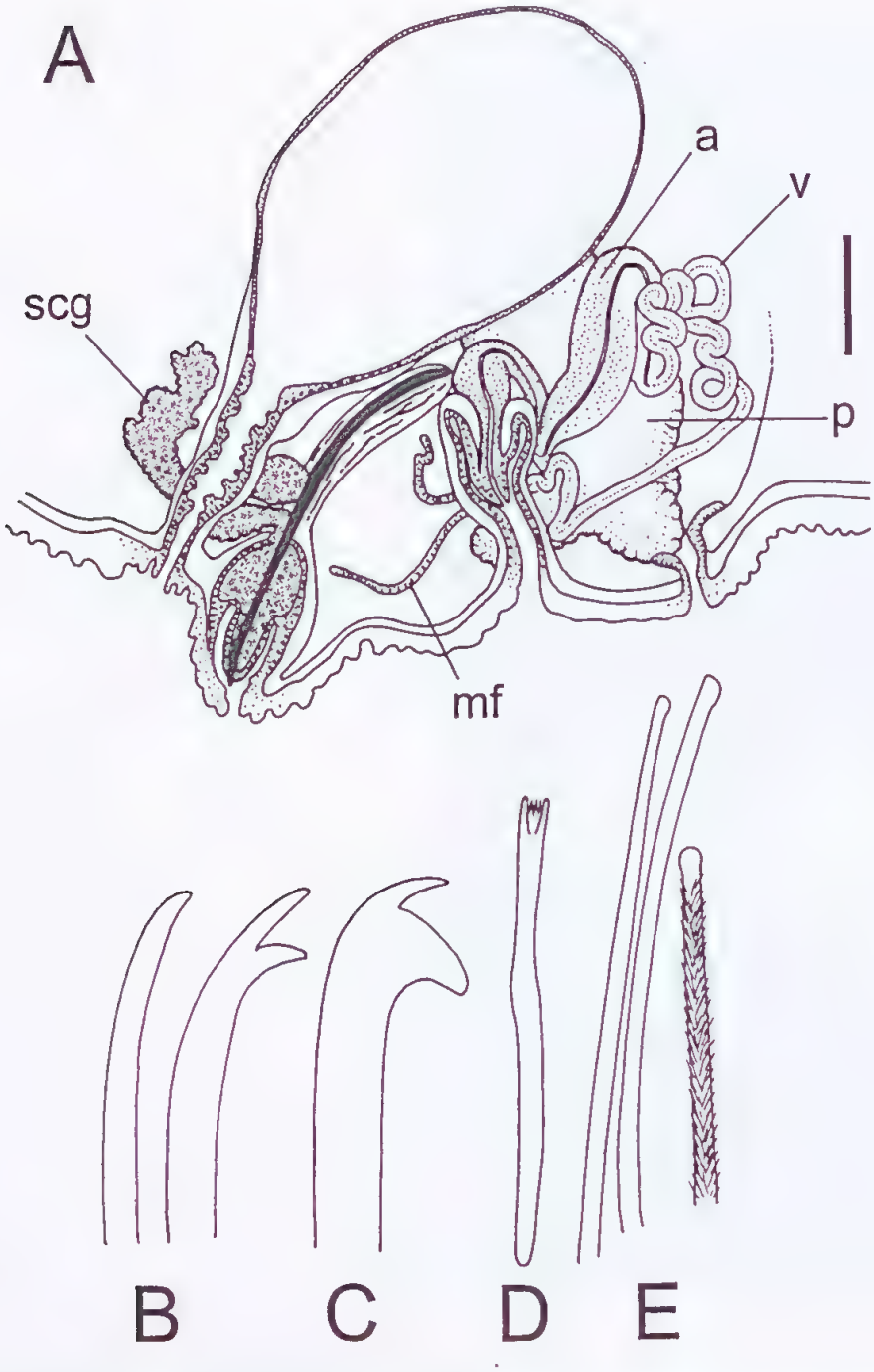

FIGURE 2. *E. yamaguchii*. **A**, Reconstruction of genitalia (with organs drawn in the same plane for simplicity) from serial sections of SAM E3095; **B**, tips of anterior ventral chaetae; **C**, tip of posterior ventral chaeta; **D**, dorsal pectinate chaeta; **E**, tips of dorsal hair chaetae, with plumosity shown for one hair. Scale bar for A 200 µm.

penes within thin-walled muscular penis sacs attached to the dorsolateral body wall by numerous muscle fibres. Penes and penis sacs with cuticle no thicker than on body wall (ie without penis sheaths). Male pores in line with ventral chaetae on anterior half of XI, within a common transverse depression of the ventral body wall. Spermathecal ampullae variable in size (770–1350 µm long), each containing 1 or 2 long thin spermatozeugmata (length of only one whole spermatozeugmata measured, 660 x 45 µm, but others 80 µm wide in cross-section, indicating greater length). Spermathecae with stout ducts (300–370 µm) that are constricted ectally, leading to pores anterior on X slightly medial to line of ventral chaetae. Spermathecal chaetae long (510–670 µm) and thin (10 µm) with grooved tips, ectal half lying in well-developed chaetal sacs. The sacs tall (220–300 µm) and muscular, with inner lining tissue that can be everted with the tip of the chaeta

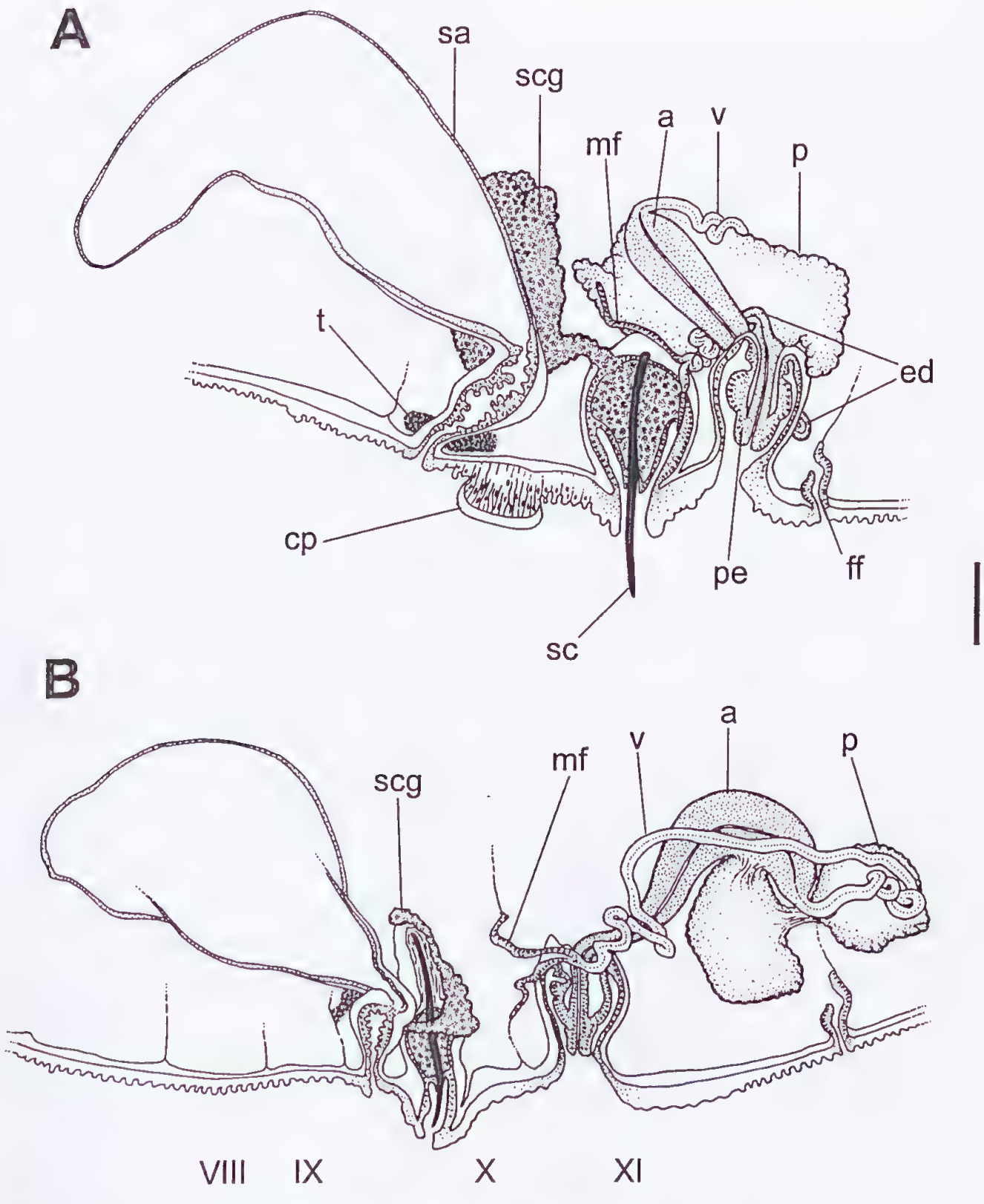

FIGURE 3. *E. yamaguchii*. Reconstruction of genitalia (with organs drawn in the same plane for simplicity) from serial sections of **A**, SAM E3096 and **B**, SAM E3097. Scale bar for A 200 µm.

to form a large papilla and with muscular layer extending to cover the ental end of the chaeta. Sacs with a gland attached dorsally, varying in extent of development (between and within individuals). Spermathecal chaetal sacs located asymmetrically, both opening slightly ventral to the line of somatic ventral chaetae, 1 immediately posterior to spermathecal pore on one side and the other close to 11/12 in front of the sperm funnel on other side. Female funnels posterolateral on XI.

Remarks

The presence of simple-pointed chaetae on segments II to VIII, separate openings for the spermathecal ducts and spermathecal chaetae, dorsolateral ridges on anterior segments and asymmetrical location of the spermathecal chaetae clearly ally these Australian specimens with the Japanese species *E. yamaguchii* rather than with any of its congeners. We initially considered that the Australian specimens were either conspecific with *E. yamaguchii* or represented a very similar sister-species. The latter was seen as more likely since *E. yamaguchii* is known only from Lake Biwa in Japan and other *Embolocephalus* seem to have fairly restricted Holarctic distributions. However, a thorough comparison of *E. yamaguchii* (from the description in Ohtaka 1994 and material seen by us) and the Australian specimens led to the conclusion that there was no morphological justification for a new species description. The only differences between the Australian and Lake Biwa specimens are the size of the worms and the size of some genital organs. None of the Australian specimens reach the maximum length of 35 mm measured for the *E. yamaguchii* neotypes (Ohtaka 1994), but most Lake Biwa specimens are less than 30 mm (Ohtaka pers. comm.). The vasa deferentia of the Australian specimens are narrower than those (20–24 µm wide entally, 40 µm ectally) recorded for *E. yamaguchii* by Ohtaka (1994) and the ectal portion is not so enlarged relative to the ental portion. However, the vasa deferentia of Lake Biwa specimens measured by us (as narrow as 13 µm entally to a maximum of 25 µm ectally) more closely match measurements from the South Australian material. Other components of the genitalia (atria, spermathecal ampullae and spermathecal chaetae) are slightly larger in the Australian specimens than recorded by Ohtaka (1994). The raised epidermal pad was not noted for *E. yamaguchii* by Ohtaka (1994) but was present on Lake Biwa material seen by us and is visible in Fig. 4B of Ohtaka (1994). This feature is not known for other *Embolocephalus* species.

These specimens represent the first records of this species and genus in Australia and one of the few records of the genus from southern continents. The known distribution of this species (Lake Biwa in Japan and the Mount Lofty Ranges in South Australia) is exceptional within the Australian tubificid fauna. Other tubificids found in Australia are either endemic or cosmopolitan (occurring in most, if not all, other continents).

?*Spirosperma* sp.

Material examined

All specimens immature. WSL consultants voucher AN30: 2 in alcohol, Old Namoi River at Bullerawa Station, (Duncan's Junction) New South Wales, 30°18'05"S 149°04'00"E, 27 Jun 2000. AWT: 1 specimen, Georges River at Cambridge Avenue, New South Wales, 33°58'S 150°54'E, 1 Apr 1996; 1 specimen, Peach Tree Creek, at Weir Reserve, New South Wales, 33°45'S 150°41'E, 17 Jul 1996; 1 specimen, Second Ponds Creek downstream of Rouse Hill Sewage Treatment Ponds, 33°40'S 150°55'E, 1 Apr 1996. AP: 1 whole-mounted on slide, Plenty River at Lower Plenty, Victoria, 37°44'S 145°06'E, 10 Apr 1994, coll. S. Schreiber (formerly Monash University); Glenelg River at Rocklands, Victoria, 37°14'S 141°57'E, 3 Jun 1994, coll. S. Schreiber. NMV F81865: 1 in alcohol, LaTrobe River at Moe-Willow Grove Road Bridge, Victoria, 38°11'18"S 146°15'12"E. NMV F81864: 1 in alcohol, Curdies River, Victoria, 38°20'S 143°08'E, 7 Feb 1992, coll. G. Quinn (formerly Monash University). AWQC voucher 5665: 1 in alcohol, Pilby Creek outlet (AWQC site 13095), South Australia, 33°59'S 140°53'E, 24 Nov 1998, coll. D. Schulze and T. Venus.

Brief description

Prostomium retractable within mouth. Body wall densely papillate, with foreign material

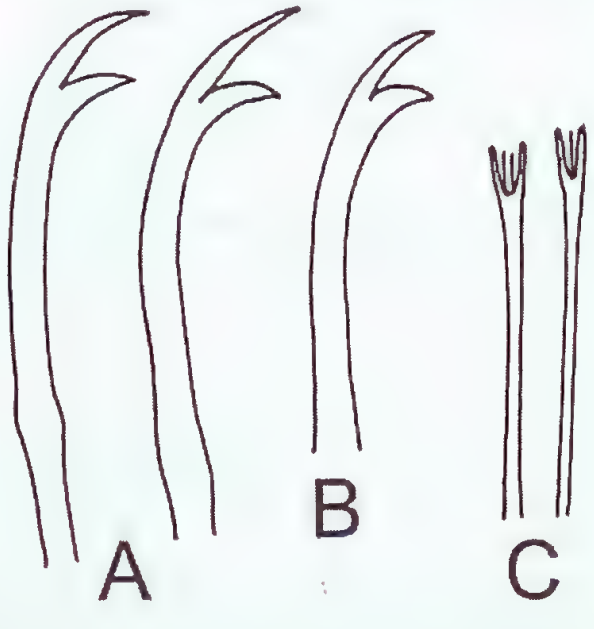

FIGURE 4. *Spirosperma* sp. **A**, ventral chaetae of anterior to mid-body segments; **B**, ventral chaeta of posterior segment; **C**, tips of dorsal crotchet chaetae.

attached to most papillae. Some papillae with foreign matter on lateral walls only. Without rings of distinctly larger papillae. Ridges of enlarged epidermal cells absent on anterior segments. Ventral chaetae (Fig. 4) all bifid, 3 to 6 per bundle, with upper teeth 2 to 3 times as long as lower teeth in anterior and mid-body segments, 1.5 times as long as lower teeth in posterior segments (Fig. 4). Ventral chaetae of first few segments usually slightly longer and thicker than the rest. Dorsal bundles with 1 to 3 smooth hair chaetae and 1 to 3 very small crotchet chaetae with finely bifid ends and 1 or 2 intermediate teeth (Fig. 4).

Remarks

This species lacks simple-pointed chaetae anteriorly and so has been tentatively identified as a *Spirosperma* rather than an *Embolocephalus*, but mature specimens are required to confirm the generic affiliation. It appears to be widespread in rivers of southeastern Australia.

Acknowledgments

Specimens of *E. yamaguchii* were collected as part of the Monitoring of River Health Initiative funded by the Land and Water Resources Research and Development Council and Environment Australia. Funding from the Wildlife Conservation Fund of the Department for Environment and Heritage (South Australia) enabled identification to species of oligochaetes from the above project. Laboratory and microscope facilities were made available by Stuart Halse (Department of Conservation and Land Management). Specimens of *Spirosperma* were made available by Australian Water Technologies, Alena Glaister at Monash University and Kylie Swingler at WSL Consultants (specimens from a Department of Land and Water Conservation NSW project). Akifumi Ohtaka (University of Hirosaki, Japan) kindly provided material of *E. yamaguchii* from Lake Biwa and engaged in useful discussions with the authors. Gordon Thomson (Murdoch University, Perth) performed the serial sectioning and Jane McRae (Department of Conservation and Land Management) assisted with photography.

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EARLY ABORIGINAL FISHING TECHNOLOGY IN THE LOWER MURRAY, SOUTH AUSTRALIA

PHILIP A CLARKE

CLARKE, PA. 2002. Early Aboriginal fishing technology in the Lower Murray, South Australia. *Records of the South Australian Museum* 35(2): 147–167.

The early Aboriginal fishing technology of the Lower Murray region of South Australia is described and compared with other areas in south-eastern Australia where fish was a dominant dietary component of hunters and gatherers. This is a study of cultural geography, the chief concern being a description of hunting and gathering techniques and their significance to Aboriginal occupation of the landscape.

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Introduction

Aboriginal fishing technology in the Lower Murray region is discussed from the pre-European period to the early years of European settlement. A major aim is to describe how hunting and gathering techniques used by Lower Murray people made their region culturally distinctive (Fig. 1).[1] This region is defined as the area from Cape Jervis in the west, east to Wellington on the Murray River and south to Kingston, taking in the whole of the Lower Lakes, Coorong and associated coastal belt. It is estimated that just prior to European settlement, the region supported a population of 5000 Aboriginal people, although this figure was probably seriously affected by two early waves of smallpox (Brown 1918: 230; Campbell 2002: 119–133; Clarke 1994: 57–63; 1995: 156, footnote 1; Gale 1969). The descendants of these people, many of whom still live in the region, generally call themselves Ngarrindjeri (Berndt & Berndt 1993; Clarke 1994; Hemming & Jones 2000; Jenkin 1979).[2]

In the Lower Murray region the Murray River flows from Murray Bridge to Lake Alexandrina through an open valley cut across a very low and flat limestone karst plain, which is less than 30 metres above sea level (Fenner 1931: 81–83; Twidale 1968: 148–149, 383–384). Below Wellington, the river becomes two large lakes (Alexandrina and Albert) and a series of channels in the form of a delta, eventually exiting behind scattered islands at the Murray Mouth.[3] Here, the river meets the Coorong, which drained the South East region of South Australia before European intervention.[4] The sea, winds and tides combine to drive the river back with heavy sand dune systems, called Sir Richard and Younghusband Peninsulas (northwest and southeast parts, respectively).[5] From the point of view of the early Aboriginal inhabitants, the delta of the Lower Murray provided the region with many kilometres of shoreline for hunting and gathering activities.

The climate of the Lower Murray region is influenced by the powerful 'controls' of its temperate latitude, the proximity of the sea and the relief of the land (Fenner 1931: 125; Howchin 1909: 142; Penney 1983: 85–93; Schwerdtfeger 1976: 75–86). Upstream, long sections of both the Murray River and its main tributary, the Darling

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1 Hunting and gathering practices in the region since the 1940s are discussed elsewhere (Clarke 2002).

2 The Ngarrindjeri (= Narrinyeri) were formerly made up of descent groups who spoke one of several dialects, such as Ramindjeri, Yaraldi (= Jarildekald) and Tangani (= Tanganekald).

3 Lake Alexandrina is called 'Lake Victoria' on some early official maps (Cockburn 1984: 7).

4 The Coorong was formerly known as the 'South East Branch' in reference to Lake Alexandrina, which it joined at Pelican Point (Cuique [R. Penney] in the *South Australian Magazine*, September 1842, vol. 2: 18–23).

5 Due to the action of the ocean currents, the location of the river exit into the sea is constantly moving; at present it is migrating northwards towards Goolwa at the rate of several metres per year (F. Tuckwell, pers. comm.). The complete disappearance of Barker Knoll at the Mouth as early as 1859 (Linn 1988: 78) indicates that some movement is a natural feature.

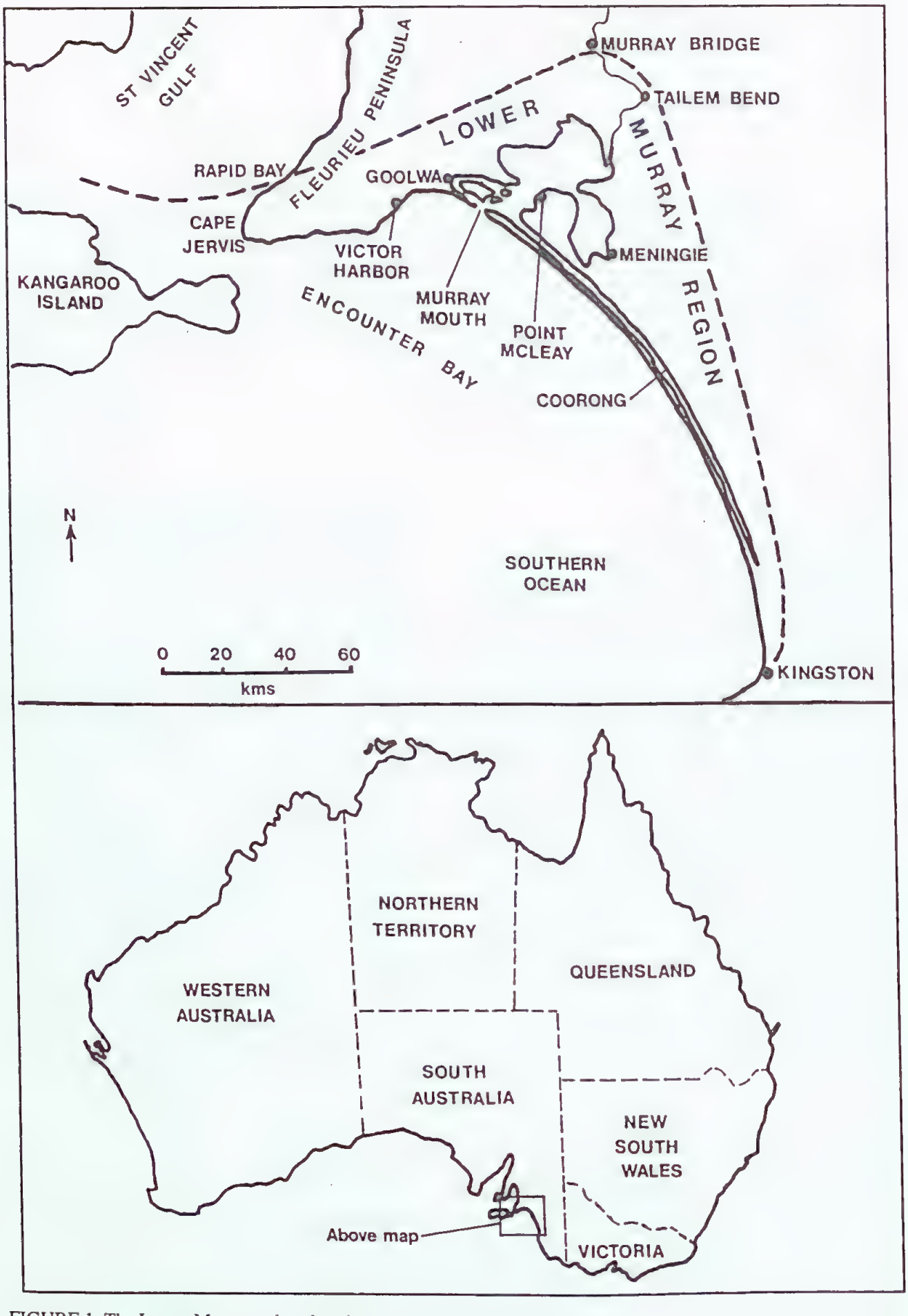

FIGURE 1. The Lower Murray cultural region.

River, flow through semi-arid regions. Nevertheless, the Lower Murray region is entirely contained within the high rainfall area of South Australia, receiving 350–750 mm per year. It comes under the rainfall shadow of the Mount Lofty Ranges to the west, with precipitation also increasing near the coast. Annual average temperature throughout the region is less than 18°C, with the greatest range of temperatures being during the summer months (Fenner 1931: 65, 126; Griffin & McCaskill 1986: 50–51; Laut et al 1977).

Sources of Aboriginal Environment Use Data

The literature of Aboriginal hunting and gathering technology for the region is based on four main sources of data — the archaeological record, the historical ethnographic record, scientific analysis of the properties of naturally occurring substances and contemporary research with Aboriginal people. This paper deals mainly with historical ethnographic sources of information, which includes artefacts collected from living people. Archaeological investigations provide evidence of the importance of fish in the diet of coastal/riparian Aboriginal groups, with an indication of the material cultural items and the main species fished.[6] Biological analysis of human bone also assists in determining the pre-European diet (Pate 1997, 1998, 2000). Scientific methods of analysis of food sources, such as those determining the pharmacological and nutritional properties, can illustrate their potential human uses. The literature investigating the usefulness of Australian fish as food and medicine includes Brand Miller et al (1993: 222–223), Clarke (1989: 3) and Isaacs (1987: 153–164). Nevertheless, cultural perceptions influence the potential use of plants and animals, with not all available resources being fully utilised. To understand how Lower Murray Aboriginal people used their environment, and thereby moulded their cultural landscape, we must at present rely primarily on records made by early European observers, supplementing this with ethnographic data from contiguous riparian/coastal regions.

Although useful data on pre-European plant use, such as species identification, method of use and seasonality, can be obtained from contemporary fieldwork with Aboriginal people, there are significant post-European changes in Lower Murray Aboriginal culture and in the physical landscape itself. For instance, information received from Lower Murray Aboriginal people in recent times on bush foods used during the last 50 to 60 years indicates far less use of roots than before (Clarke 1988: 64). In contrast, other indigenous foods such as fish, waterfowl, kangaroos, emus and berries continued to be used in restricted contexts. Nevertheless, the introduction of foreign species, such as European carp, and environmental changes in the waterways have decreased numbers of some Australian fish species. The availability of European-type foods, especially flour, potatoes and canned foods, obtained from missions, farm stations and towns led to a decline in many indigenous food sources. The decrease in 'bush food' consumption was particularly marked for those species requiring significant labour expenditure. Other foods were replaced by European varieties with more favourable properties. The bulrush root, for example, contains a great deal of fibre that makes eating difficult. Unlike earlier Aboriginal foods, many European sources were available at all times of the year because they were imported.

The detailed recording of Aboriginal culture in the Lower Murray region started with the German Heinrich A. E. Meyer, who ran a mission at Encounter Bay during the late 1830s and early 1840s (Meyer 1843, 1846). From him we obtain a Ramindjeri-speaker's view of Lower Murray culture. The Englishman George Taplin established an Aboriginal mission at Point McLeay on the south-western shore of Lake Alexandrina in 1859. In the 1870s he published two main books on Ngarrindjeri (= Narrinyeri) culture, based on records in his journals (Taplin 1859–79, 1874, 1879). Taplin used Ramindjeri sources as a guide to his research, although local Aboriginal groups living around Point McLeay were mainly Yaraldi-speakers. He described people who were feeling the impact of European expansion and the considerable changes it had brought upon them and the Lower Murray landscape, particularly at the northern end. One of Taplin's initiatives to improve their circumstances was to establish a local fishing industry for Aboriginal people at the mission (Jenkin 1979: 97–98, 110–111).[7]

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[6] For an archaeological overview of the Lower Murray / South East districts, see Campbell (1934, 1939, 1943), Campbell et al (1946), Luebbers (1978) and Pretty et al (1983).

[7] There are many entries in Taplin's journals concerning the establishment of the fishing industry. The important references are 21 September 1859, 18 October 1859, 25 November 1859, 22 December 1859, 11 January 1860, 7 February 1860, 15 February 1860 and 1 March 1860.

Adding to the missionary records in the 19th century are the recordings of colonists such as George French Angas (1847a, 1847b), William A. Cawthorne (1844 [1926]), Dirk M. Hahn (1838–39), Richard Penney (1840–43)[8] and William Wells (1852–55). During this century, various anthropologists studied Lower Murray Aboriginal culture: Ronald M. Berndt (1940; with Catherine H. Berndt 1993), Alison Harvey (1939ms, 1943) and Norman B. Tindale (1930–52, 1931–34, 1934–37, 1935, 1937, 1938, 1938–56, 1941, 1981, 1987; with Mountford 1936; with Pretty 1980). Their accounts are rich in detail concerning past hunting and gathering practices, filling many gaps that were left in the early historical record. They also contain examples of post-European innovations by indigenous people. Largely due to the interests and efforts of the Director of the South Australian Museum, Edward C. Stirling, and Ethnology Curator, Norman B. Tindale, the South Australian Museum possesses a large collection of early artefacts from the Lower Murray region.[9] In the 1980s the present author commenced studying Aboriginal relationships to the physical landscape (Clarke 1985a, 1985b, 1986a, 1986b, 1987, 1988, 1989, 1994 chapter 4, 1998, 1999b, 2001a). The region and Aboriginal relationship to it also featured in the Hindmarsh Island Bridge controversy (Bell 1998; Stevens 1995; Wilson 1998). The attention that scholars have directed towards the Lower Murray has meant that it is ethnographically one of the best-described regions in southern Australia. The biases within this literature are discussed elsewhere (Clarke 1994 section 11.3, 1999a: 149–151, 2001a: 19–20).

Early Aboriginal Fishing Technology

In the pre-European period the high Aboriginal population along the river frontage and the coastal zone of South Australia was in sharp contrast to the sparse population in the interior. In the Murray Basin region the distribution of people was estimated to be 0.4–0.5 square kilometres for each individual, in contrast to 31–88 square kilometres required in Central Australia (Jones 1974: 326; Lawrence 1968: 72–73; Maddock 1972 [cited Rose 1987: 22–23]; Meggitt 1962 [cited Abbie 1976: 46–47]; Smith 1980: 68–90; Tindale 1981: 1860). It has been demonstrated that the physical environment of the Lower Murray formed both a natural and cultural region (Clarke 1994). Stable isotope research on human bone indicates that, in general, neither people nor foods were moving from the Murray Bridge area to the adjacent Murray Mouth and Coorong (Pate 1998). The Lower Murray therefore formed a separate hunting and gathering region. Nevertheless, some aspects of the material culture and natural resource use by Aboriginal people here was similar to that of riverine and coastal communities described from elsewhere in Australia (Hallam 1975; Lawrence 1968: 85–122; Lourandos 1997: 195–243).

In the 1930s Tindale mapped many of the favourite fishing places and lookouts in southern South Australia, from informants such as Louisa Eglinton (Narangga woman), Milerum (Clarence Long, Tangani man) and Albert Karloan (Yaraldi man).[10] In the Tangani language, elevated areas used as 'watch places' were called *popaldi*, whereas in Ramindjeri they were *koinkoinj*.[11] Older men generally used these when looking out for fish shoals and bird movements, as well as for monitoring the movements of their neighbours by observing the smoke from their campfires. In comparison to adjacent regions, such as the Murray Mallee and Mount Lofty Ranges, the Lower Murray landscape offered Aboriginal people abundant opportunity to make fish a more significant food source.

Before the arrival of Europeans, Aboriginal people in southern Australia did not widely use the fishhook and line (Curr 1883: 110; Davies 1881: 129; Eyre 1845, vol. 2: 266–267; Massola 1956; Meyer 1846 [1879: 192]; Olsen 1991: 5).[12] Nevertheless, the use of bone bi-points or fish gorges (*muduk*) and fishing lines has been recorded from along the Murray River (Flood 1999: 48; Gerritsen 2001; Pretty 1977: 321–322). Similar items have been recorded from the

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[8] Newspaper articles by Richard Penney between 1840 and 1843 are reprinted in the *Journal of the Anthropological Society of South Australia* 1991: 1–107.

[9] From 1988 to 1999, a major exhibition on Aboriginal culture in the Lower Murray, called 'Ngurunderi, a Ngarrindjeri Dreaming', was open at the S.A. Museum (Hemming & Jones 2000).

[10] Tindale Aboriginal Site Maps of southern South Australia, South Australian Museum Archives, Adelaide. Also see Tindale (1935–60: 15).

[11] Tindale (no date, 'Milerum', Stage A, #9, Archives, South Australian Museum, Adelaide).

[12] Tindale (1934–37: 285) recorded a description by Karloan (Karlowan) of fishhooks being made from bone, gum and stick, but this was possibly a post-European development.

Gippsland and Geelong areas of southern Victoria (Smyth 1878 vol. 1: 391). Shell fishhooks have also been recovered from coastal shell middens in eastern Victoria (Mulvaney & Kamminga 1999: 292).

After Europeans arrived, Aboriginal people in the Murray River and Lower Murray regions adopted new fishing techniques and appeared to have made their own version of the fishhook.[13] In 1938 Tindale recorded Albert Karloan who said:

> Our fish hook was made from a bone of a kangaroo tied like a real fish hook to another piece which was the point but our old folks used the fish spear all the time; nothing was as good as the real fishing spear! We walked along the banks & got fish in the reeds (Tindale 1930–52: 42).

European twine, hooks and lines were also handed out at the Point McLeay Mission (Taplin Journals: 18 September 1862). Fishing techniques used in the Lower Murray region included netting, spear and club fishing, trapping and opportunistic collecting.

Net-Fishing

The Ngarrindjeri people referred to the act of netting fish as *ngerin* (Taplin 1879: 130). Marine net fishing often involved the coordination of a large number of people. Worsnop provided a vivid account of Aboriginal people sea fishing in the 19th century. He records:

> In Encounter Bay I have seen the natives fishing almost daily. Two parties of them, each provided with a large net, square in form, with a stick at either end, and rolled up, swam out a certain distance from the shore, and then spread themselves out into a semicircle. Every man would then give one of the sticks round which his piece of net was rolled to his right hand man, receiving another from his left hand neighbour, bringing the two nets together, thus making a great seine. They now swam in towards the shore, followed by others of their number, who were engaged in splashing the water and throwing stones, frightened the fish and prevented their escape from the nets (Worsnop 1897: 90–91).

George French Angas painted two men fishing with a seine net at Second Valley, south of Adelaide, in 1844 (Angas 1847a: Plate XXI). Cawthorne provides a similar scene, in watercolour, at Second Valley, dated c.1842 (figure in Hemming & Jones 2000: 9), as does Snell in his sketches, dated 14 July 1850, at Yorke Peninsula (Snell 1849–59 [1988: 128]). Eylmann (1908: 375 & Plate XXXIV fig. 3) published a drawing of two Ngarrindjeri men using a long seine net, with a third man helping to drive the fish in. It is likely that several nets were sometimes connected together with supporting sticks.[14] In situations where nets were not available, branches could be used to drive the fish up on the beach (Angas 1847b: 112). A former colonist wrote to Tindale stating that in the Port Germein area, north of Adelaide:

> On occasions a wall of prickly bushes was built in about three feet [one metre] of water and rolled shorewards, the ends converging to an arc. The fish which were impaled or caught were extracted by the pushers and thrown to others following behind (Parkes 1936, cited in Tindale 1935–60: 48).

The 'wall' of branches, comprised of saltbush and mangrove, was called *winda* and required two people to roll it and two more for picking out the fish (Parkes 1936, cited in Tindale 1935–60: 96).

Net fishing in fresh water required fewer people than sea fishing, with small nets used to catch fish living amongst reeds and logs. Nets were essential items of Lower Murray material culture for fishing in the lagoons of the Lower Lakes, Coorong, Murray River and in the creeks of the southern Fleurieu Peninsula. In the Encounter Bay area, Aboriginal women also caught tadpoles from claypans with fine meshed nets and cooked them in large 'mutton-fish' shells (Worsnop 1897: 83).

There was some degree of specialisation in the nets used by Lower Murray people. Harvey (1943: 111) described three main types of nets used by Yaraldi-speaking people of the Lower lakes. Nets with a small mesh, *jatrumi* [pronounced 'yatrumi'], were used when fishing for *kanmuri* (mullet, *Aldrichetta forsteri*). The nets with a larger mesh, *neri*, were used for *tukkeri* (bony bream, *Nematalosa erebi*). The big drum nets, *dongari*, were mainly for catching *pondi* (Murray cod, *Maccullochella peeli*) found under large logs

[13] In 1932 Tindale (1953: 42) recorded from a European named Arthur White that Aboriginal people living along the river had used a double-pointed wooden fishhook. Tindale (no date, 'Milerum', Stage A, #3, Archives, South Australian Museum, Adelaide) also claimed that they used a fishing toggle made from bone as a form of fishhook.

[14] This technique was also used in southern Yorke Peninsula (Tindale 1936: 57).

submerged in the river.[15] The drum nets were made with sticks in the form of a rectangular pouch (Harvey 1943: 111).

The Tangani people of the Coorong used specialised nets, such as the *jataruma* [pronounced 'yataruma'] to catch mullet and the *donggari* to catch mulloway (*Argyrosomus hololepidotus*) and other big fish (Tindale 1934–37: 226). They also used the *ngeiri* net, which was made from the same sedges that were collected for basket and mat making. All nets used by Tangani people in the pre-European period were for hauling (Tindale 1934–37: 226). The Tangani used a hooped fishing net, termed *kandarangku*, with a mesh of 2.5 cm, for larger fish (Tindale 1951: 258). Apparently the term is a play on words meaning 'widow catcher', as *kandari* is applied to coarse rope and *rangku* refers to a widow.[16] Murray River people around Moorundie used the same type of net, *kanderunku*, to catch *ponku* (Murray cod).[17] The Kingston people used a net called *pinang kanji* to round up fish in shallow waters (Tindale 1931–34: 89). Angas provided a small watercolour painting of a pouch-like net 'for taking very small fish from Lake Bonney' (Angas 1847a: Plate LI) in the South East of South Australia.

Aboriginal people in southern South Australia probably did not use set nets until well after European settlement. Tindale's main Lower Murray informant, Clarence Long (Milerum), claimed that set nets were rarely used in the Coorong when he was younger, and not at all before then (Tindale 1934–37: 226). This suggests that Europeans had introduced the practice to the local Aboriginal people. From available accounts, sinkers and floats were not used in association with net fishing during the pre-European period of southern South Australia. The record of Murray River people using clay from wasp nests to make sinkers for set nets is probably a post-European innovation.[18] Tindale (1935–60: 17) suggested that vegetation placed along the top of the net to prevent fish from jumping out of the water might have helped keep the net vertical.

It is likely that in the pre-European period most fishing nets in southern South Australia and Victoria were fabricated from two-ply string made from fibre obtained from the roots and stems of the bulrush (*Typha* species) (Beveridge 1883: 42; Krefft 1862–65: 361; Tindale 1935–60: 17; Zola & Gott 1992: 8–9, 62). Europeans also know this plant as flag, cumbungi and reed mace, whilst contemporary Ngarrindjeri people refer to it as *manangkeri* or *manakeri* (Clarke 2001b). It was a major food source, with the chewed remains of the roots being generally in good supply in Aboriginal camps (Clarke 1988: 69–70, 72; Tindale & Mountford 1936: 497). Tindale stated that:

> ... mature rhizomes were chewed and fibres made into string, the chewing for this purpose being a duty of women. Older women's teeth were often worn to the gum line by their constant chewings.[19]

He also suggested that the proximity of bulrush grounds would have made a good riverside camp.

In 1894 an Aboriginal man from Point McLeay, Jacob Harris, provided a detailed written account of net making from 'rushes', which were probably bulrushes. He said that before Europeans arrived, Aboriginal people in the Lower Murray region used to:

> make our nets almost the same as the Europeans did, the meshes were the same, the only difference being that yours [Europeans] were made of twine etc., while ours from rushes. The rushes had to be steamed or cooked or whatever you like to call it, first a hole was dug, say a couple of ft. [= 60 cm], then a fire was placed in it, after it had burned almost to ashes some damp or wet grass was put on the coals, then the rushes, so that the steam arising from the grass would steam or cook ... put in about evening and left until morning, it was then taken out and divided among the camp to chew or suck the juice out of it, which is very sweet, it was then made or twisted into a line for to be made into a net. ... the meshes were the same [as European nets].[20]

Angas stated that the marine fishing nets were 'composed of chewed fibres of reeds, rolled upon

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[15] Descendants from the Yaraldi and Maraura people from the Lower Lakes and Murray River regions made S.A. Museum drum net, A21338, in 1934.

[16] Tindale (no date, 'Milerum', Stage A, #3, Archives, South Australian Museum, Adelaide).

[17] Tindale, 'Ngaiawung vocabulary', Archives, South Australian Museum, Adelaide. Also see Scott (cited Tindale 1951: 258).

[18] Tindale (no date, 'Milerum', Stage A, #3, Archives, South Australian Museum, Adelaide).

[19] Tindale (no date, 'Milerum', Stage A, #3, Archives, South Australian Museum, Adelaide).

[20] J. Harris letters (D6510(l)14,15, Mortlock Library, Adelaide). Tindale (1934–37: 164) received a similar description of the process from his Ramindjeri informant, Reuben Walker.

the thigh, and twisted into cord for the purpose' (1847a: Plate XXI).[21] Emu oil was sometimes rubbed into the fibre while it was being made into two-stranded cord (Tindale 1931–34: 60). Fibre treated in this manner makes the string more supple, while maintaining its strength and durability. Tindale (1951: 257) maintained that Aboriginal cordage from all areas of Australia was always composed of single or two-ply twists, never three or more. Nevertheless, there some were exceptions. For instance, West (1999: 20, 23–28) describes the making of three-ply rope in Arnhem Land and possibly Tasmania.

After European settlement, changes in the Aboriginal diet would have led to a significant decrease in the availability of fibre from bulrush roots. Fibre used by Lower Murray people to make string for nets also came from an unidentified plant known in the local Aboriginal language as *calgoonowrie* (MacPherson, no date: 10). A plant recorded as used for making Coorong nets was *kuka* (native flax, *Linum marginale*).[22] In 1932 an informant from the Maraura people of the Upper Murray of South Australia, Frank Fletcher, said that gill nets and drag nets were both made from the *pungur* rush (Tindale 1953: 23).[23] Harvey (1943: 109–110, 112) stated that the stems of *jalkeri* (knobby club rush, *Isolepis nodosa*) were used for making nets.[24] But field investigations have indicated that the stems of this rush are pithy and not suitable for making string or baskets. The stems of *mangatu* (spiny sedge, *Cyperus gymnocaulos*) would have been better; this species is still used by local Aboriginal people who make baskets and mats from it.[25] Nets made from sedge stems were also made for dry uses, such as catching ducks.[26]

The technique used to make nets in southern South Australia has been variously described as 'knotted netting' or 'knotted looping' (Davidson 1933: 257–259, 269–272, figs 1, 9–10; West 1999: 30–33, 49). The Tangani people called the mesh of the net, *mandar*, which reputedly meant 'the eyes'; the netting knot or tie was *mulbakan* and the act of making a net was *lagulun* (Tindale 1934–37: 226). The last term is a reference to the threading motion of making the knot being like 'spearing'.[27] In the Ramindjeri language of Encounter Bay, *lakk-in* was recorded as 'spearing; weaving (as rushes for a basket)' (Meyer 1843: 74). The mesh sizes for nets in southern South Australia were variable, in the range 1–2.5 cm with the Kongarati Cave fragments, 2.5 cm recorded for the Coorong hoop net and 8 cm for netting wrapped around a desiccated body found at Fromm Landing, Murray River.[28]

Spear and Club Fishing

During the day, men caught fish such as *malawe* (mulloway, *Argyrosomus hololepidotus*) by standing motionless in the river or in their canoes (Hemming & Jones 2000: 9; Meyer 1846 [1879: 192–193]; Smith 1930: 230–231; Snell 1849–59 [1988: 182]; Tindale 1934–37: 7). Fishers attracted the fish by their shadows and stabbed them with hand-held spears. Large spears made from *Callitris* pine with two to three wooden prongs lashed to the head were used for spearing mulloway and Murray cod.[29] Being large, these spears were also used as punting poles when fishers were travelling on bark canoes and rafts (Hemming & Jones 2000: 9). It is likely that these spears were hidden near the area of their use when the fishing season was over. In the Lower Lakes area fishermen frightened fish from their hiding places by a large noise, created by thrusting one

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[21] A supporting reference is Angas (1847b: Plate LVI). An example of a net made from *Typha* fibre is A2000, collected from the Lower Lakes district.

[22] Tindale (no date, 'Milerum', Stage A, #3, Archives, South Australian Museum, Adelaide).

[23] The term *pungur* may relate to the *punggurtko* specimen of *Juncus* species collected by Tindale from Swan Reach, 5 August 1964 (A68584, South Australian Museum). If so, then the plant referred to for net-making was probably of the same species. Similarly, a related term, *puungort*, is a Western Victorian Aboriginal term for the basket sedge, *Carex tereticaulis* (Robson 1986).

[24] This plant was formerly known as *Scirpus nodosus*.

[25] Examples of River Murray fishing nets made from sedges (*Cyperus* species) in the South Australian Museum include specimens A17529, A21338, A26250, A45090. The term *mangatu* was recorded from Aboriginal sources in the 1980s (Clarke 2001b).

[26] See figure in Hemming & Jones (2000: 13). Satterthwait (1986: 39–40) provided an overview of the use of nets for catching waterfowl in Aboriginal Australia.

[27] In the Ngarrindjeri language of the Lower Lakes, *lakelun* was recorded to mean 'spearing' (Yallop & Grimwade 1975: 33–34, 85–86).

[28] Tindale (1951: 258) reported on specimens A65091, A25351 and A20616, respectively. Smyth (1878: 389–390) discussed mesh sizes for Victorian nets.

[29] In 1936 Tindale collected a 3.1 m-long fishing spear (Museum specimen A26093) made of pine from the Coorong. This specimen has two prongs lashed to the head and was called *punkularipuri ma:wantj* in the Tangani language. In 1844 G. French Angas painted a close-up of a large spear with three prongs lashed on (Angas collection, Archives, South Australian Museum, Adelaide — see Angas 1847b: Plate XXX). This watercolour is reproduced in Hemming & Jones (2000: 9).

of these pronged spears into the water (Unaipon 1924–25 [2001: 19]). The compressed air caught between the prongs rose to the surface with a loud report. There is an account of spear-fishing competitions held from November to April among the Piltindjeri group of Yaraldi-speaking people living along the southeastern shore of Lake Alexandrina, with the fish caught being presented to senior people in the community (Smith 1930: 231–236; Unaipon 1924–25 [2001: 19–24]). In this instance, it required skill in fish tracking, involving the detection of movements in pondweed, reeds and water ripples.

At night, a fire was used to attract fish to be struck by spear or club (Angas 1847b: 112). Angas painted a club called a *wadna*, which was 'used by the Port Lincoln natives, to throw at fish whilst swimming' (Angas 1847a: Plate LI). Similar bent elongated clubs from the Lower Murray are also in the Museum collection. Clubs like these and described as boomerangs were reported as used along the Coorong (Olsen 1991: 5). Sometimes a bark canoe was used as a platform to fish from, with a fire contained by a clay hearth in the middle that also served to cook the catch (Angas 1847b: 54, 101, 107; Meyer 1846 [1879: 193]).[30] Mobility across water was important for the fisherman in order to reach areas favoured by particular species of fish. Therefore, rafts made from reed stems (*Phragmites australis*) and grasstree flower-stalks (*Xanthorrhoea* species) would also have been important items of fishing material culture in the Lower Lakes and along the river lagoons.[31] Although relatively common along the Murray River and in the Lower Lakes, bark canoes were rarely seen in the Coorong lagoon, and even then only for bringing in trade items.[32] Red gum trees (*Eucalyptus camaldulensis*) required for bark are found only in permanent freshwater regions, such as along creeks in the southern Fleurieu Peninsula and along the Murray River. There is no evidence that any form of watercraft was ever used for sea fishing, although short trips were made on reed rafts or floats to nearby rocky islands in order to kill seals there (Tindale 1941: 241).

Opportunistic Harvesting

There are documented cases of Aboriginal use of fish poisons in small lagoons of the upstream reaches of the Murray River bordering northern Victoria (Curr 1883: 110). Nevertheless, Taplin doubted that Ngarrindjeri people possessed knowledge of the use of poisonous plants (Taplin 1879: 47). When large numbers of fish died for natural reasons, such as changes in salinity in the river or lake, Aboriginal people quickly gathered them (Eyre 1845, 2: 266). Before the construction of the barrages across the Murray Mouth separating the Coorong from Lake Alexandrina, elderly Aboriginal informants interviewed in the 1980s claimed that there were sometimes rapid changes in the water from fresh to saline (Clarke 2002). This tended to kill a large number of fish, providing an abundant but temporary source of food. At other times, the incoming salt water drove certain species, such as Murray cod, upstream and suspended fishing in the lakes until it receded (Olsen 1991: 8; Taplin Journals: 19 May 1860). Bony bream also die off seasonally in large numbers and, according to Ngarrindjeri informants in the 1980s, they had provided a temporary windfall of food (Clarke 2002).

Fish-Traps and Enclosures

Fish-traps and enclosures ranged from slight modifications to natural features of the landscape to special purpose-built structures (Mulvaney & Kamminga 1999: 34–35). For example, in some areas Aboriginal people were able to use the narrowing of the channels between swamps as traps in which to place netted bags. In his diary Wells records:

> Just now [July] there is fish to be had out of the swamps, and we got one of the native females to make us a net. They are made of a long kind of soapy platt [sic.], but flat and round, quite as large as an umbrella top. It is then doubled not unlike a huge ankle boot, and at the two ends there is a small opening. It is then raised from the bottom in such a way that the fish when

[30] The South Australian Museum has a bark canoe (A6443) from Avoca Station on the Darling River that contains an early 20th century mock-up made by museum artisans of the fireplace for display. The original fireplace was made in a mud-lined wooden container (A53554).

[31] Jacob Harris, an Aboriginal man at Point McLeay writing in 1894, claimed that the use of the 'rude kind of raft' made from reeds predated the use of bark canoes in the Lower Murray (J. Harris letters, D6510(L) 14,15, Mortlock Library, Adelaide). The South Australian Museum holds raft specimens (A14632, A14633) made by a Yaraldi woman, Amy Johnson, in 1930.

[32] This statement derived from accounts by Meintangk woman, Ethel Watson, and Tangani man, Clarence Long (Milerum) (Tindale 1931–34: 69, 87).

> caught cannot return. The net is then fastened with sticks in a narrow channel where one swamp runs into another and all fish going with the stream are caught. These fish the blacks call Coogolthee. The nets are laid overnight and by break of day next morning we have plenty brought us for breakfast.[33]

On the frontier of British colonisation, wild foods and Aboriginal labour were often crucial to the survival of European settlers (Clarke 1996). Examples of more active manipulation of the environment were the construction of long trenches by Aboriginal people to concentrate fish, in the long term saving them much labour expenditure. For instance, Smith records that in the Murray region:

> In the low-lying country, alongside of the river, trenches are dug two or three hundred yards [180 or 270 metres] long and from four to five feet [1.2 to 1.6 metres] deep. When the Murray becomes flooded it overflows its banks to the extent of a mile or more [1.6 kilometres or more] on each side, and frequently the Murray cod, the bream, the butterfish, and other fish are living in this water. When the waters become low through evaporation and soakage the fish are easily caught ... They wade into the shallow water and scoop the fish into baskets made especially for this purpose (Smith 1930: 229).

These channels were often relatively large modifications of the landscape that would have had a significant impact upon the local watertable (Lourandos 1997: 219–22).

Another modification of the landscape for fishing was the building of stone and wooden fish-traps. Some fish-traps, probably the predominantly wooden ones, were known by the Ngarrindjeri name, *ku:yitaypari*.[34] The Yaraldi people in the Lower Lakes did not make such structures, preferring to use fishing spears instead (Tindale 1931–34: 73–75). In the Coorong fish were harder to spear due to the prolific waterweed, so the Tangani relied heavily upon stone fish-traps, *talaipar* (Tindale 1931–34: 73–75). Areas of shallow water in the Coorong, such as at the Yungurumbar crossing place, were considered good places for making such stone fish-traps (Tindale 1931–34: 71).[35] The Tangani generally placed their fish-traps made from limestone blocks along the landward shore of the Coorong (Tindale 1974: 61–62). This was presumably because the water here is shallow and covers a limestone shelf, in contrast to the seaward side of the Coorong lagoon, which is deep and sandy. Tindale provided a detailed record of the construction and use of fish-traps or, as his informants called them, 'fishing-stations' (Tindale 1931–34: 73–75, 1934–37: 5). The fish-traps were generally made in the shape of a V, with one of the walls, termed *nganangkure* or *ngalde*, connecting with the bank. The wall that extended into the Coorong lagoon was sometimes up to 30 metres long. The basketware trap was placed at a gap in the base of the V. The species of fish seasonally caught in the traps included *kongoldi* (probably congolli), *njindumi* (an eel species), *palengoi* (unknown species), *lapalap* and *therugarai* (unknown fishes, not found in the Lower Lakes) and *teri pateri* ('sand mullet') (Tindale 1931–34: 75, 1934–37: 5).[36] No attempt was made to drive the fish in, relying solely on their natural movements.

At Noonamena, on the mainland side of the Coorong near Meningie, the tops of silted over fish-trap formations can still be seen. Aboriginal people interviewed by the present author in the early 1980s said that these fish-traps were naturally formed stone structures that were previously modified and maintained with stones and pieces of wood. According to Ngarrindjeri man Jack Koolmatrie, mullet travel northwards up the Coorong during the day (Ely 1980). Upon reaching the trap, fish would swim into the wide mouth of a horseshoe-shaped line of rocks. The foundation of this was a natural reef of exposed rock with all gaps except one narrow exit shored up with logs and boulders. The mullet were forced to travel through this narrow exit where a net or basketry container put in their path would catch them.

Elsewhere in southern Australia, some of the fish-traps have been described in the literature as

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[33] Wells, 16 July 1853. The species of fish referred to here is probably *kungali* (congolli, *Pseudaphritis urvilli*) (Clarke 2001b).

[34] Yallop & Grimwade (1975: 55) list *ku:yiti* as 'rushes, sticks', and *ku:yitaypari* as 'fish-trap, barrier of sticks'.

[35] The Yungurumbar crossing place is probably that between Rabbit Island and Junggurungbar (pronounced Yunggurungbar), a hill on the Younghusband Peninsula (see Tindale 1938, fig.1).

[36] The eel species referred to here is probably *Anguilla australis*. The *palengoi* was said by Tindale to be equivalent to the Yaraldi *pelingi*. This is probably the *pelanggi* that Berndt & Berndt (1993: 308) described as 'mudfish' or 'butterfish'. The *lapalap* may possibly have been a species of *Galaxias*. In the case of *teri pateri* or 'sand mullet', Tindale (1931–34: 74) said that its Yaraldi name is *weialapi*. This is probably the same word as the 'welappi' or 'mullet' recorded by Taplin (1879: 131). Eckert & Robinson (1990: 19) consider that this refers to the 'jumping mullet' (*Liza argentea*).

weirs.[37] According to Edward J. Eyre, Aboriginal people seasonally gathered at the channels around Moorundie that connected the river flats with the Murray River:

> making a weir across them with stakes and grass interwoven, [would] leave only one or two small openings for the stream to pass through. To these they attach bag nets, which receive all the fish that attempt to re-enter the river. The number procured in this way in a few hours is incredible. Large bodies of natives depend upon these weirs for their sole subsistence, for some time after the waters have commenced to recede (Eyre 1845, 2: 253).

This practice occurred during early December when the Murray River floods had already reached their highest point and were beginning to recede. Further south, in the shallow waters and swamps of Lake Frome near Burr Range, small fish were caught in weirs (Angas 1847b: 174). Also in the South East, near Rivoli Bay, Angas recorded:

> On some of the swamps the natives had built weirs of mud, like a dam wall, extending across from side to side, for the purpose of taking the very small mucilaginous fishes that abound in the water when these swamps are flooded (Angas 1847b: 155).

In the pre-European period, Aboriginal modification of the riverine landscape for fishing must have been considerable. It was oral history among old river boat captains in the 1980s that before the lock system was introduced, remains of Aboriginal built fish-traps were known hazards to paddle-steamers when the water level was low (T. Sim, pers. comm.). Hahn recorded that in the Hahndorf area of the Mount Lofty Ranges, the Aboriginal people would:

> build a dam into the river, high enough to let about a foot [31 centimetres] of water stream over it. Because of this dam, the fish in their run must come close to the surface of the water, where the savages stand in readiness to spear them (Hahn 1838–39 [1964: 133]).

In coastal zones weirs of brushwood constructed at mouths of creeks caught fish left by receding tides (Angas 1847b: 112). Some of the trenches, traps and weirs were designed to catch bait for much larger fish. For example, near Martin Well on the Coorong, drains 100 m in length were constructed by Aboriginal people to catch small fish, called *lap-lap*, for bait (Worsnop 1897: 106).[38] These were netted in fine close mesh nets. These weir and trench constructions appear similar in design to the much larger earthworks at Lake Condah in western Victoria.[39]

Outside the Lower Murray, but elsewhere in southern South Australia, fish-traps have been recorded in the Port Lincoln estuarine area (Martin 1988; Mountford 1939), as well as at the mouth of Pedlar Creek south of Adelaide (Stapleton & Mountford, no date). In the case of the latter, the Tangani man, Milerum, knew of these traps as he and his family camped there, when he was a child, on their way to Adelaide via the coast.[40] There were also fish-traps made from large water-worn boulders at Moana Cove, also south of Adelaide, but these were in poor condition when Tindale inspected them in the 1920s.[41] Some traps could be dragged out of the water when fish were not required. For instance, Charles Sturt stated that on his 1830 expedition down the Murray River he:

> observed some cradles, or wicker frames, placed below high water-mark, that were each guarded by two natives, who threatened us violently as we approached. In running along the land, the stench from them plainly indicated what they were which these poor creatures were so anxiously watching (Sturt 1833, 2: 165).

Small dams or 'pounds' might not only be structures for catching fish, but were also used to keep part of the catch alive for future use. At the Point McLeay Aboriginal Mission, 'fish pounds' made of stakes were in common use by Aboriginal people during George Taplin's period there (1859–79).[42] According to Lower Murray man

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[37] For example, Beveridge (1883: 48); Curr (1883: 110) and Pretty et al (1983: 119). Tindale listed 'fish weir (set in creek)' as *ake* in a Murray River dialect (Tindale, 'Ngaiawung vocabulary', Archives, South Australian Museum, Adelaide).

[38] This fish, *lap-lap*, was possibly a species of *Galaxias*. *Lapps Lapps* was recorded to mean 'small fish' in the Booandik language (Smith 1880: 3). Wells (1852–55) listed *lap-lap* as 'very small fish'. Tindale (1931–34: 74) said that *lapalap* were a Coorong fish species not known in the Lower Lakes.

[39] For a description of the Lake Condah eel-traps, see Coutts et al (1978); Flood (1995: 240–245; 1999: 216–220); Hemming (1985); Robson (1986) and Worsnop (1897: 104–106). The S.A. Museum has a basketry trap, A6431, collected from Lake Condah, c.1910 (see figure in Hemming & Jones 2000: 9).

[40] Tindale (no date, 'Milerum', Stage A, #3, Archives, South Australian Museum, Adelaide).

[41] Tindale (no date, 'Milerum', Stage A, #1, Archives, South Australian Museum, Adelaide).

[42] The 'fish pounds' were recorded by Taplin on the shore of Lake Alexandrina (Journals, 11–12 October 1859; 8 November 1859; 11 November 1859; 28 November 1859; 10 January 1860; 21 November 1861; 20 March 1862).

Lindsay Wilson, interviewed by the present author in the early 1990s, the practice of fish storage in wooden enclosures in the lake at Point McLeay continued until the 1930s. During the early twentieth century along the Coorong, European fishermen kept alive the bream they had caught by putting them in 'pounds' made of tea-tree stakes, until the weather was suitable for transporting them to the market (Evans 1991: 40).

Cultural Aspects

Aboriginal people along the Murray River considered that their Dreaming Ancestors created the wetlands that provided them with abundant sources of food. For instance, Natone, an Aboriginal man from the South Australian section of the Murray River, claimed that a blind woman, Noreela, had created the environs of the river (Bellchambers 1931: 112, 125). Starting from Lake Victoria, Noreela, with two young children to guide her, made the river by driving back the sea. She travelled like a 'drunken bee'; her meandering course meant that the river was very long. This lengthening of her journey was considered greatly desirable, as it increased the number of fishing and hunting grounds, with a lagoon at each elbow. The fossils jutting out of cliffs along the Murray River were said by Aboriginal people to be the remains of fish killed and eaten by Noreela and her children. Another account, still told by Ngarrindjeri people in the 1980s, was of a Thukabi Ancestor, who was a large river turtle that came down the Murray River:

> Thukabi [a large river turtle] came down [from the Darling district] through the desert looking for a place to lay its eggs. As she went, the drag of its tail made the river, its flipper carved out the lagoons and banks. You can see where it went. When it got to the lake, it pushed itself into the sea (H. Rankine cited Clarke 1994: 114).

In all these accounts, the present course of the Murray River is explained by the actions of Ancestral Beings.[43]

In the Ngarrindjeri Dreaming of the Lower Murray, Ngurunderi chased a large Murray cod, Pondi, down the Murray River, widening its banks in the process, until it was eventually speared near the Murray Mouth (Berndt & Berndt 1993: 224; Clarke 1995: 148–149; Hemming & Jones 2000).[44] Whilst Ngurunderi was at the Murray River entrance into Lake Alexandrina, a water spirit known as the Mulgyewonk tore holes in his nets, which prevented him fishing for his family (Tindale & Pretty 1980: 50). There are accounts of Aboriginal legends from further upstream in Murray–Darling Basin where the dreaded river spirit who fed on boys was a large Murray cod (Sinclair 2001: 120–121, 252). Ngurunderi made the fishing grounds and lookouts for the Lower Murray people, which is told in song (Tindale 1931–34: 259).

Fish species also appear elsewhere in Lower Murray mythology. For instance, Yamakawi (Shark Ancestor) had a prominent role in the Kondoli (Whale Ancestor) Dreaming of Encounter Bay, which explained the origin of fire (Clarke 2001a: 24–25). There is also a Dreaming myth relating predominantly to freshwater fishing technology, which took place in the region from Lake Hindmarsh in western Victoria to Lake Alexandrina in the Lower Murray (Harvey 1939ms, 1943; Tindale 1934–37: 65–69). In this account the drum-nets of the pelicans were transformed into large pouches under their bills. In the Dreaming of Limi (= Lime), the love of eating fish is involved in explaining the creation of the Inman and Hindmarsh Rivers of the southern Fleurieu Peninsula (Berndt & Berndt 1993: 311; Meyer 1846 [1879: 202]).[45] The Skyworld landscape contains a fish too, with a constellation of stars being Nunganari, the Stingray (Berndt & Berndt 1993: 164, fig. 25; Clarke 1997: 131).[46]

Economically important fish species were considered by the Lower Murray people to have been created by Ancestors during the creation period. For instance, in a Ramindjeri account of the Kondole (Whale) Dreaming, the Kuratje and Kanmari Ancestors became small fish when they ran in the sea:

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[43] From the late 1980s, an animated version of this myth was given at the Signal Point Museum, Goolwa.

[44] Sinclair (2001: 120) speculated that the relatively large size that some cod grow to, up to 1.8 metres, enhanced Aboriginal beliefs of the beast's mythical qualities.

[45] Berndt & Berndt (1993: 311) suggested that Limi was a Stingray or Carpet Shark Ancestor. Meyer (1843 part 2: 75) listed 'Lime' as a 'kind of seal'. Limi and his family were eventually transformed into a group of prominent rocks in the sea at Victor Harbor near the Bluff (Meyer 1846 [1879: 202]).

[46] According to Tindale (no date, 'Milerum', Stage A, #1, Archives, South Australian Museum, Adelaide), the Tangani considered that there were seven stars shaped like a stingray.

> The latter was dressed in a good kangaroo skin, and the former only a mat made of seaweed, which is the reason, they say, that the kanmari [mullet, *Aldrichetta forsteri*] contains a great deal of oil under the skin, while the kuratje [Western Australian salmon, *Arripis truttaceus*] is dry and without fat (Meyer 1846 [1879: 203]).[47]

In other Dreaming accounts, the Murray cod, Pondi, was cut into smaller pieces by either Ngurunderi or Waiyungari, depending on the myth version, and thrown back into the water to become different types of fish (Clarke 1995: 148; 1999b: 53–54).

The Ramindjeri version of the Ngurunderi myth epic, recorded from Reuben Walker in 1935, starts from a large lake near mountains somewhere to the northeast of the Lower Murray and involves a large fish which is not a Murray cod:

> Ngurunderi came to the Lake and speared the fish which, made off with it at a great speed and cut a deep track right down to Lake Alexandrina. Ngurunderi followed and noticed that the river thus formed was without fish. So he stood on the bank and broke the bark of the red gum tree (*wuri*) up into shreds & threw it into the water and said; you are Murray cod. This must be true because, when you cut open a Murray cod you can see a tree like mark of blood vessels on the walls of its body; it is just like a gumtree. Ngurunderi then threw in *pujulanki* bush (Native wild grape? *Cryptandra hispidula*) and this became catfish (*Tandanus tandanus*). He threw in peppermint gum bark (*tentumi*) and it became the *tjiri* (*Terapon bidyanus* Mitchell). After he had made all the best fishes he threw in a piece of refuse and it became the Bony bream (*tukari*, *Fluvialosa richardsoni* (Caselman)).[48]

In relation to the blood vessels, it is worth noting that along the Murray European fishers have an analogous belief which interprets the tree-like markings on cod swim bladders as 'skin maps' that show the birth place of the individual fish (Sinclair 2001: 124–127). Tindale recorded from a European settler the following Dreaming account involving Matumeri who:

> ... chased a large fish from the sea entrance of the Murray Mouth up through the Lake until he caught it out off Poltallock [Poltaloch Station] where he killed it and pulled it to pieces and threw the pieces all about and they turned into small fishes and that is how the different sorts of fish came (RD Anderson 1934 [cited in Tindale 1934–37: 175]).

The Ancestor mentioned here is probably Matamai, who was Ngurunderi's son (Clarke 1995: 146). The theme of an Ancestor tearing up large beings to make many smaller species also occurs in relation to kangaroos according to one account of the Waiyungari mythology (Clarke 1999b: 54).

Aboriginal people considered themselves as having a role in the continuation and wellbeing of their environmental resources. Ceremonies were sometimes performed in order to increase fish supply. For instance, Howitt relates:

> There is a spot at Lake Victoria [= Lake Alexandrina], in the Narrinyeri [= Ngarrindjeri] country, where when the water is, at long intervals, exceptionally low, it causes a tree-stump to become visible. This is in charge of a family, and it is the duty of one of the men to anoint it with grease and red ochre. The reason for this is that they believe that if it is not done the lake would dry up and the supply of fish be lessened. This duty is hereditary from father to son (Howitt 1904: 399–400).

The illicit involvement between Waiyungari and Nepeli's wives in the Ngarrindjeri Dreaming was perceived as the cause of poor fishing in early spring each year. The arrival of the Young Men (Orion) and the Women (Pleiades) constellations in September was considered to help turn this around (Berndt & Berndt 1993: 164; Clarke 1999b: 57). The flowering of certain plants may also have been an indication of the arrival in the Lower Murray of certain species of fish. This was the case at Marion Bay in Yorke Peninsula, where the prolific flowering of tea-trees was a sign to the Narangga people that the mullet fish were soon to come in large numbers.[49] Here, it was claimed that initiation ceremonies were held then to take advantage of this seasonally abundant food source.

The abundance of fish would have allowed for a larger Aboriginal population in the Murray Basin in comparison to the surrounding regions. The Lower Murray was particularly rich in fish resources, involving marine, estuarine and freshwater species (Eckert & Robinson 1990; Evans 1991; Glover 1983; Olsen 1991; Sim et al 2000). Angas said 'The Milmenduras subsist

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[47] Identification of these fish names is given by Eckert & Robinson (1990: 19–20). Note that *kuratye* is equivalent to *kuratje*.

[48] Tindale (1930–52: 119). [Italics by the present author.]

[49] Reminiscences recorded by E. Davies in the *Mail* newspaper, Adelaide, on 25 March 1952.

chiefly on fish, and though extremely wild and treacherous, present some of the best specimens of the Aboriginal Inhabitants, as regards physical appearance' (Angas 1847a: Plate XI). Angas also commented that 'On the S. E. coast and along the shores of the Murray and Lakes Alexandrina and Albert the natives live chiefly upon fish, and waterfowl' (Angas 1847a: General Remarks).[50] Aboriginal people considered that some of the spirits with whom they shared the landscape also liked eating fish. For example, Lower Murray people believed that the dreaded river spirit, the Mulgyewonk, was attracted to the smell of fish and once captured a young boy who was washing fish oil from his hands on the edge of the lake (Clarke 1999a: 157; Harvey 1939ms).

From the daily account available in Taplin's Journals, it is clear that fish, termed *mame* in general, were a favourite food item in the Lower Murray region. Ngarrindjeri people considered that the dominance of fish in their diet set them apart from at least some of their neighbours. They gave cultural significance to the fact that when their babies tried to speak, their first word was *mam* (Taplin Journals: 10 October 1861). Adults proudly interpreted this as the infant's desire to eat fish. The fish entrails, *ngarakuni*, were considered good eating, being grilled over the coals with the edges of the fillet curled up to catch the juices.[51] Special sticks, *wunupi*, were used as fire tongs to remove food, such as fish, from hot coals.[52] Fish remains are often found in Aboriginal middens on the banks of the Lower Lakes and Murray River (Luebbers 1978, 1981, 1982; Pretty et al 1983: 117–118; Tindale 1930–52: 67).

Some Aboriginal groups in southern South Australia were noted by their neighbours for having a diet dominated by fish. This is shown by a recorded remark by Parnkalla people of northeastern Eyre Peninsula that their Port Lincoln neighbours, the Nauo, had 'an offensive breath, being fish eaters' (Schürmann 1844, 1: 7). In the Lower Murray, Murray cod oil was rubbed on initiates (Tindale 1930–52: 139). The Tangani people of the Coorong had a song 'ridiculing men who refused to lend their fishing net' (Tindale 1934–37: 267).

The material culture of the Lower Murray people reflected their fishing background. Old fishing nets were used in the Murray Basin for wrapping human bodies that had already been desiccated (Sheard et al 1927: 173; Tindale 1951: 258; Tindale & Mountford 1936: 495, 499). In the Lower Murray, fishing nets were often among the personal items placed in burial bundles lodged on tree platforms (Hackett 1915: 29). Stingray tail barbs or 'nails' were used in *ngildjeri* sorcery (Berndt & Berndt 1993: 260). In the Murray River area, Tindale recorded the medicinal use by Nganguruku people of Eucalyptus leaves, *tindunj*, with fish fat. Apparently they would 'infuse leaves in bark dish over hot ashes, mix with fish fat (liver) for colds'.[53] Angas painted an object that he described as '*Kaikoonga* – Bones of a fish found in the Murray, worn as a head ornament, in the same manner as the teeth of the kangaroo' (Angas 1847a: Plate XXX). String-games or 'cats-cradles' played by Lower Murray and South East women and children often featured 'fishing nets' (Tindale 1931–34: 88).[54]

The wide distribution of recorded modifications to the landscape to assist in capturing or storing fish in the Lower Murray and neighbouring coastal and riverine areas indicates that their use, in pre-European times, was a major subsistence strategy. Lourandos has described some earthworks by Aboriginal people in temperate southern Australia as artificial drainage systems operating to flush fish from swamps into channels set with traps (Lourandos 1997: 219–221, 227). This form of swamp management coped with excess water during floods and helped retain water in times of drought. This was part of a subsistence pattern that allowed for a larger and semi-sedentary human population, in comparison to other regions. The material culture and diet of Aboriginal people living in the south would therefore have significantly differed from groups to the north and particularly those situated some distance away from major bodies of water. Fish

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[50] Supporting references are Angas (1847b: Plates IX & XXV).

[51] Harvey (1939ms) and Tindale (1930–52: 248–249) sketched the manner in which fish were cut up and have given the Yaraldi names for the pieces.

[52] Tindale & Mountford (1936: 496). See photograph in Hemming & Jones (2000: 17).

[53] N.B. Tindale specimens (A68579 – *Eucalyptus oleosa*; A68585 – *E. foecunda*; A75835 – unknown *Eucalyptus* species) collected '3 miles north of Swan Reach', 5 August 1964. Clarke (1989: 3) has a similar record relating to mulloway liver.

[54] In 1930 Tindale collected a string-game (A14962), called 'fishing net', from Amy Johnson (Yaraldi people, Lower Lakes). A string-game (A66733), described as a Tangani 'fish net game' from the Coorong, was possibly a replica made by Tindale in 1934 (see Hemming & Jones 2000: 19). In 1930 D.S. Davidson and N.B. Tindale collected at Swan Reach a string-game (A14958), called a 'net', made by Jerry Mason (Yiraruka people, Murray River).

storage in pounds and mud pools was a pre-European Aboriginal practice for managing the windfall/drought situation of food gathering. Another Lower Murray technique to extend the use of fish food in pre-European times was to dry fish on racks (Berndt & Berndt 1951: 29). Because of the highly seasonal nature of fishing, it is likely that some of the stone and wood structures found in southeastern Australia, identified by archaeologists as fish or eel-traps, would be better described as fish pounds, being for storage rather than capture.

Among the Lower Murray people, many of their totemic familiars, the *ngaitji*, were species of fish (Berndt & Berndt 1993: 306–312). This was also the case for totemic groups along the Murray River (Tindale 1953: 37, 49). In their daily life, menstruating women in the Lower Lakes and Murray River areas were forbidden to eat fish (Berndt & Berndt 1993: 124–126, 141; Eyre 1845, 2: 295; Harvey 1939ms). These women were not allowed to go near the water at all, as it was considered that the success of men fishing would be spoiled. On one occasion in the past, a large incursion of seawater brought a considerable number of *poronti* (sea mullet, *Mugil cephalus*) into the Coorong lagoon (Tindale 1931–34: 119). In spite of their abundance, amongst the Tangani people only old men were allowed to eat them. The mulloway would swim into the Coorong lagoon to spawn under the limestone cliffs (Tindale 1931–34: 119). In this condition only old men were allowed to spear them. Similarly, if young men ate *pelenggeri* fish (unknown species), they would prematurely become baldheaded and grey (Tindale 1934–37: 39).

In the Lower Lakes no Yaraldi women, except the elderly, were allowed to eat catfish (Harvey 1939ms). Similarly, young Yaraldi girls were not allowed to eat big-bodied *kai:kuanggi* ('freshwater bream' – possibly black bream, *Acanthopagrus butcheri*). Women during menstruation were not allowed to go near water or to eat fish caught with nets, as the Yaraldi believed it would drive the fish away. In recorded versions of the Ngurunderi Dreaming, his fleeing wives cooked and ate *tukkeri* (bony bream) fish.[55] The importance of this particular episode is explained in various ways, depending on the particular account. These are that the wives were breaking a food prohibition by eating this fish species; that the fat exploded in the fish, making them sacred to Ngurunderi; and that the wives incurred Ngurunderi's wrath by giving him the smaller of the two fish they had cooked. The unifying theme in all versions is that this fish was not to be eaten by women.

In the Murray River region more restrictions were placed upon females until past the age of child bearing than upon males of the same age (Eyre 1845, 2: 293). Teichelmann stated that in southern South Australia, food prohibitions were such that women with children were prohibited from eating certain food and that they generally lived upon vegetables (Teichelmann 1841: 7). The categories of people with least amount of food prohibitions appear to have been infants and the elderly. Eyre said that in the Murray River area 'No restrictions are placed upon very small children of either sex, a portion being given to them of whatever food their parents may have. About nine or ten years appears to be the age at which limitations commence' (Eyre 1845, 2: 293–295). He also stated that old men and women were able to eat most things. All prohibitions would have been based on cultural logic, even if the reasons were obscured from those practising the ritual. People generally excluded from prohibitions were those not sexually or economically active. It was the power to produce, either physically or spiritually, at particular life stages that was perceived as making people sensitive to influences potentially harmful to group harmony. In a sense, an individual's position in the society could be defined by what the person could eat and what economic activities they could engage in. The major categories determining prohibitions appear to have been age, gender and initiation status.

Aboriginal people could, at certain times, exercise a degree of choice in the food they lived on. For instance, some Lower Murray animal foods such as fish, emu and kangaroo meat were highly favoured foods when available. Yet vegetable foods such as roots were probably the mainstay when meat was not easily obtainable (Clarke 1988: 73–74). A report from the Adelaide-based Statistical Society in 1842 illustrates the seasonality of Aboriginal food in the southern areas.[56] The report notes that in

[55] Accounts summarised from Berndt & Berndt (1993: 224, 435), Clarke (1995: 149, 1999b: 54) and Tindale (1934–37: 285).

[56] 'Transactions of the Statistical Society. Report on the Aborigines of South Australia.' *Register* newspaper, 8 January 1842. Thomson (1939) also considered the seasonal aspects of Aboriginal culture.

spring mainly vegetables and grubs were eaten. With the commencement of summer, fish were obtained, as were kangaroos, emus, lizards and the eggs and young of birds. During the hottest part of the year possums and acacia gum were procured, while in autumn berries and nectar were available. In the winter a variety of roots were consumed, as were possums and other animals.

The coastal zones of southern South Australia were rich in natural resources, particularly food such as fish, molluscs and coastal berries. Meat from occasional whale strandings was also an attractive coastal food source (Clarke 2001a). Although many of these foods were available for the greater part of the year, the onset of winter made the coast a harsh zone in which to live. Partly for this reason, 'salt water' Aboriginal groups in southern South Australia would have moved according to season between inland and the coast. Stable isotope analysis of human bone indicates that 'salt water' groups did not penetrate up the Murray River beyond the boundaries of the Lower Murray cultural region (Pate 1997, 1998, 2000). The pattern in the Adelaide region was a general movement away from the coast in late autumn, so that more substantial shelters could be built in the protected Mount Lofty Ranges foothills (Clarke 1991: 58–59; Ellis 1976: 116–117; Ross 1984: 5; Tindale 1974: 60–61). The historical record shows similar early patterns for coastal groups from the Lower South East of South Australia (Foster 1983: 23–43). Seasonal movements, although an aspect of the Aboriginal relationship to the physical environment, are essentially dictated by the 'cultural landscape'.

A seasonal population movement occurred among at least some Lower Murray Aboriginal groups. In winter the 'salt water' Tangani people camped along the mainland side of the Coorong lagoon, where firewood was plentiful and shelter from weather available.[57] The fish-traps maintained there, where the water is shallow, provided a reliable source of food. During summer these Tangani people camped on the Younghusband Peninsula between the Coorong and the Southern Ocean, giving them easy access to coastal foods such as marine fish and berries. There were also political reasons for the movements, with the actions of neighbours impacting on Lower Murray groups. For example, one of the disadvantages of camping on the mainland side of the Coorong was that here the Tangani were open to attack from the Ngarkat people, who normally ranged in mallee areas to the east of the Lower Murray. During harsh summers the Ngarkat people were forced towards the Murray River and Lower Lakes when their water supplies dwindled, but the Tangani considered that they were not likely to be attacked during the winter. The locations of most Lower Murray seasonal camps are not known, although more archaeological research may improve our present knowledge. For 'fresh water' Lower Murray people, such as the Yaraldi-speaking groups living along the edge of Lake Albert and Lake Alexandrina, the yearly movement was probably from the lakeshore to nearby inland areas, in order to maximise food supplies and comfort (see Fig. 2). During warmer months lakeside camps were cooler as well as being close to freshwater food sources. In contrast, during winter, campsites in close proximity to large bodies of water were more exposed to cold weather. Back from the lakeside, the forests provided natural windbreaks and had more firewood and hut building materials available. The prominence of aquatic technology used by the Lower Murray people would have given them little interest in the remote and harsh inland regions.

Conclusion

Resource usage by early Lower Murray Aboriginal people was a function of the broader environmental and regional patterning of the landscape. Aboriginal people in the Lower Murray were not randomly dispersed over the landscape; Ngarrindjeri people were restricted to the riparian/marine areas that were consistent with their material culture. They were, among other things, regionally organised according to their perception and use of the natural resources. The Lower Murray people considered their relationship with the environment to be an active one. Not only did they physically manipulate their resources, they also considered themselves to be influenced and organised by the environment. The material culture of the Lower Murray people, although having some aspects in common with water-based subsistence cultures in the South East and the Murray River regions, was distinctive. They were largely a cultural group confined to the riparian/

[57] Tindale (1938: 21, 1974: 61–62).

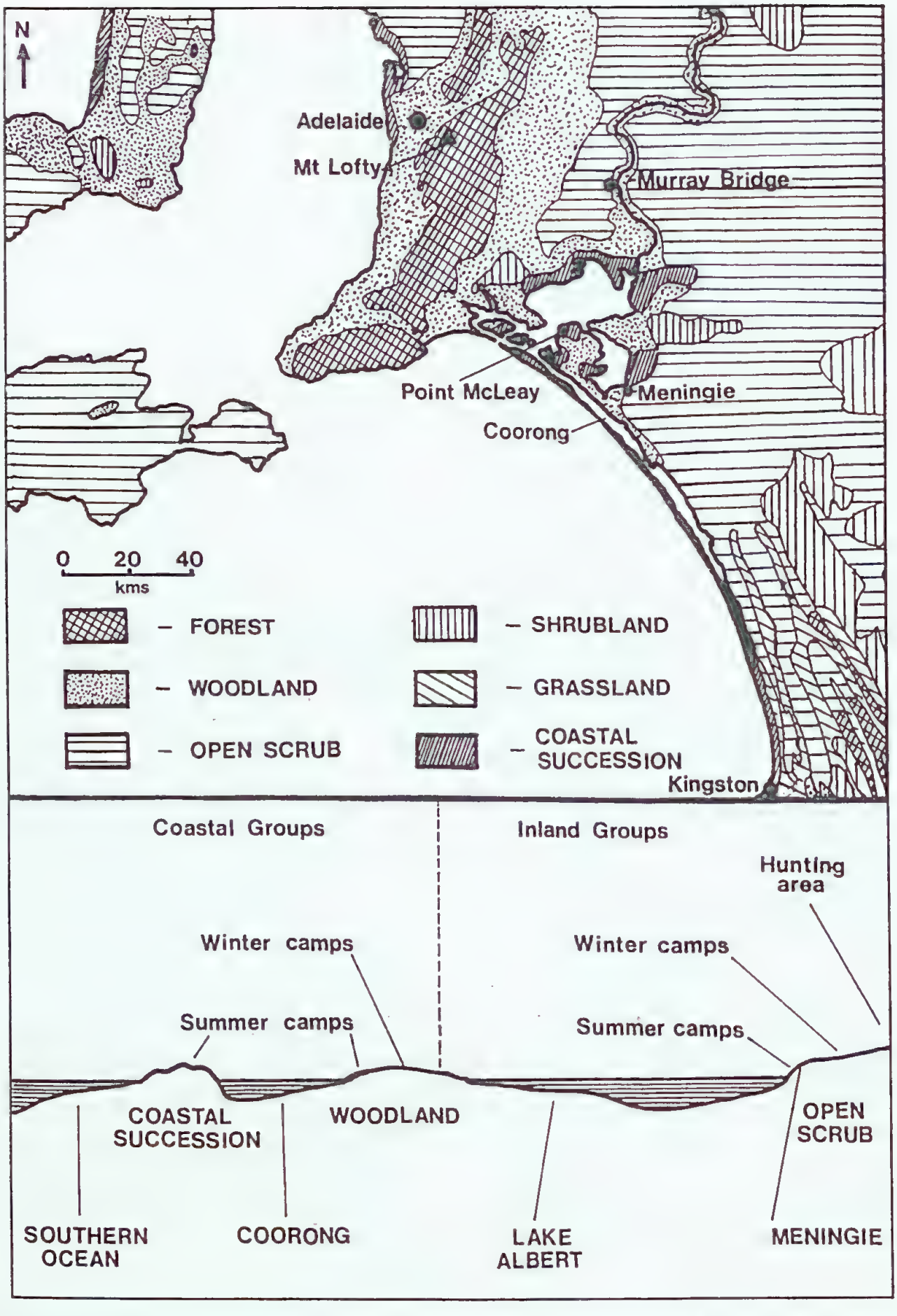

FIGURE 2. Pre-European vegetation of southern South Australia (after Boomsma & Lewis 1980: map) and Aboriginal camping zones in the Lower Murray.

coastal habitats of the southern coastal region of South Australia. Their hunting and gathering practices help to define this cultural region. Approaches in cultural geography, focusing on the cultural construction and perception of the landscape, are well suited to the study of Aboriginal environmental knowledge.

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FOSSIL LIZARDS FROM THE PLIOCENE CHINCHILLA LOCAL FAUNA, QUEENSLAND, WITH DESCRIPTION OF A NEW SPECIES

MN HUTCHINSON & BS MACKNESS

HUTCHINSON, MN & MACKNESS, BS. 2002. Fossil lizards from the Pliocene Chinchilla Local Fauna, Queensland, with a description of a new species. *Records of the South Australian Museum* 35(2): 169–184.

The lizard fauna of the Middle Pliocene Chinchilla Local Fauna consists of members of the Gekkonidae, Agamidae, Varanidae and Scincidae. A new species of the scincid lizard genus *Tiliqua* is described, based on a complete right dentary. The new species combines relatively unspecialised dentition, most similar to that of *T. nigrolutea*, with large size and relatively gracile proportions, with a relatively slender coronoid process and deeply concave margin between the coronoid and angular processes. An additional scincid dentary is probably referable to the genus *Cyclodomorphus*. Cranial remains of a species of the gekkonid genus *Diplodactylus* are described, representing a group of species within *Diplodactylus* that have a vestigial jugal. An agamid dentary and two varanids of differing sizes are also described.

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The Chinchilla Sand was named by Woods (1960) for a sequence of weakly consolidated grey to yellowish and light brown sands, ferruginised heterogeneous conglomerates, grits, sandy clay and clays. These outcrops range from shallow beds to sections several metres deep along a 40 km stretch of the Condamine River valley, approximately 240 km ENE of Brisbane.

The Chinchilla Sand has yielded a diverse array of fossil remains, the Chinchilla Local Fauna (Mackness, Wilkinson & Wilkinson 1999). Mammals have been the best studied group and the fauna recovered comprises macropodids (Bartholomai 1963, 1966, 1967, 1973, 1975, 1976; Flannery & Archer 1983), phascolarctids (Archer 1977), thylacoleonids (Archer & Dawson 1982; Bartholomai 1962; Woods 1956), peramelids (Mackness et al 2000), dasyurids (Archer 1982; Bartholomai 1971; Dawson 1982; Wroe & Mackness 1998, 2000a, 2000b), a thylacine (Mackness et al submitted), murid rodents (Godthelp 1990) and a molossid bat (Hand et al 1999). At least three lineages of birds are also known, an emu, a rail and a duck (Olson 1975, 1977; Patterson & Rich 1987). The living lungfish *Neoceratodus* and plotosid catfish have also been recorded (Kemp & Molnar 1981; Mackness et al 1999). Reptile remains described so far pertain to larger taxa, such as crocodilians (*Palimnarchus*), turtles and madtsoiid snakes (Bartholomai & Woods 1976; Gaffney 1981; Gaffney & Bartholomai 1979; Mackness & Scanlon 1998; Woods 1960, 1962). The only lizards to date have been Hecht's (1975) identification of a number of large varanid fossils from the Chinchilla Local Fauna as *Megalania* sp.

The Chinchilla Local Fauna appears to biocorrelate with the Kanunka Local Fauna of the Tirari Desert, South Australia (Tedford et al 1992) and the Spring Park, Bow and Big Sink Local Faunas (Mackness et al 2000). On the basis of the Kanunka Local Fauna having a magnetostratigraphic age of approximately 3.4 million years, the Chinchilla Local Fauna is estimated to be between late Early Pliocene and Middle Pliocene in age (Tedford et al 1992).

Lizard fossil remains have received relatively little attention in reports on Australian fossil faunas, due both to a paucity of material and a lack of data concerning osteology. In some lineages of lizards, such as agamids (Covacevich et al 1990) and varanids (Mackness & Hutchinson 2000), the restricted amount of morphological divergence within the living fauna makes identification problematic. For the anatomically diverse skinks and gekkonoids, this picture is steadily changing for the better as new finds focus attention on specific areas of anatomy. In this

study we point out some useful character states of gekkonid skulls that permit attribution to both major lineages and more restricted species groups. We also build on the knowledge of one of Australia's most characteristic lizard faunal elements, the bluetongue skinks of the genus *Tiliqua* (Shea & Hutchinson 1992) to describe a new and distinctive species.

Materials and Methods

The specimens described here were recovered through quarrying or wet sieving of sediments from 'Wilkinson's Quarry', Chinchilla, Queensland, a site that has been continuously worked by Cec and Doris Wilkinson for over 11 years. The sediments are primarily fluviatile in nature and represent a number of depositional events. Most fossils in these units occur as isolated pieces and all represent Pliocene taxa (Mackness, Wilkinson & Wilkinson 1999).

Specimens were examined using a Wild M3Z stereomicroscope with eyepiece micrometer and drawing tube. The fossils are registered in the collection of the Queensland Museum, Brisbane and were compared with skeletal material in the collection of the South Australian and Western Australian Museums. Comparative scincid specimens included all living species of *Tiliqua* and representatives from all species groups in the genera *Cyclodomorphus* and *Egernia*. The morphology of the gekkonid fossils dictated the gekkonid specimens that would be the most likely candidates for comparison, the 'unspecialised' small- to medium-sized diplodactylines. We also examined representatives of those genera of gekkonines that occur in the Australian region and the adjacent Melanesian–Indonesian region, as well as a scattering of specimens from across the global diversity of the subfamily Gekkoninae. In addition, published diagrams and discussions of gekkonid cranial osteology were consulted to ensure that our selection was representative, mainly aimed at justifying some of the general statements we make regarding major patterns of variation that differentiate gekkonine and diplodactyline skulls and mandibles. Specimens examined are listed in Appendix 1. Terminology for bones follows Estes et al (1988).

Measurements

Measurements of varanid vertebrae and the large *Tiliqua* species were made using Vernier callipers accurate to 0.05 mm, while smaller specimens and teeth were measured with a calibrated microscope eyepiece. Vertebral measurements are summarised below and largely follow Smith (1976). Statistical analyses of these measurements are provided in Appendix 2; Tables 1 and 2.

Vertebral length (Pr-Po) — the greatest distance from the anterior edge of the prezygapophysis to the posterior edge of the postzygapophysis.

Vertebral width (Pr-Pr) — the maximum width of the vertebra between the lateral edges of the prezygapophyses.

Vertebral width (Po-Po) — the maximum width of the vertebra between the lateral edges of the postzygapophyses.

Centrum minimum width (BW) — the smallest distance across the centrum.

Condylar width (CW) — the greatest transverse diameter of the condyle.

Abbreviation for specimen numbers: AR: University of New South Wales Research Collection; SAM: South Australian Museum; WPC: Wilkinson Private Collection.

Systematics

Order SQUAMATA Oppel, 1811

Family AGAMIDAE Gray, 1827

Unidentified material

Material examined

A left dentary (WPC 1354), bearing mid to rear section of tooth row.

Characters

Agamid reptiles are distinguished in having a dentition combining one to three anterior pleurodont teeth followed by acrodont teeth. Other agamid features are summarised by Estes (1983).

Description

The specimen is from a moderately sized individual, perhaps of skull length of approximately 30 mm, and bears nine acrodont teeth. The posterior of the dentary is largely missing although the facet for the coronoid is still visible. No mental foramina are discernible on the specimen.

Remarks

Covacevich et al (1990) discussed several problems in identifying fragmentary agamid remains beyond family level.

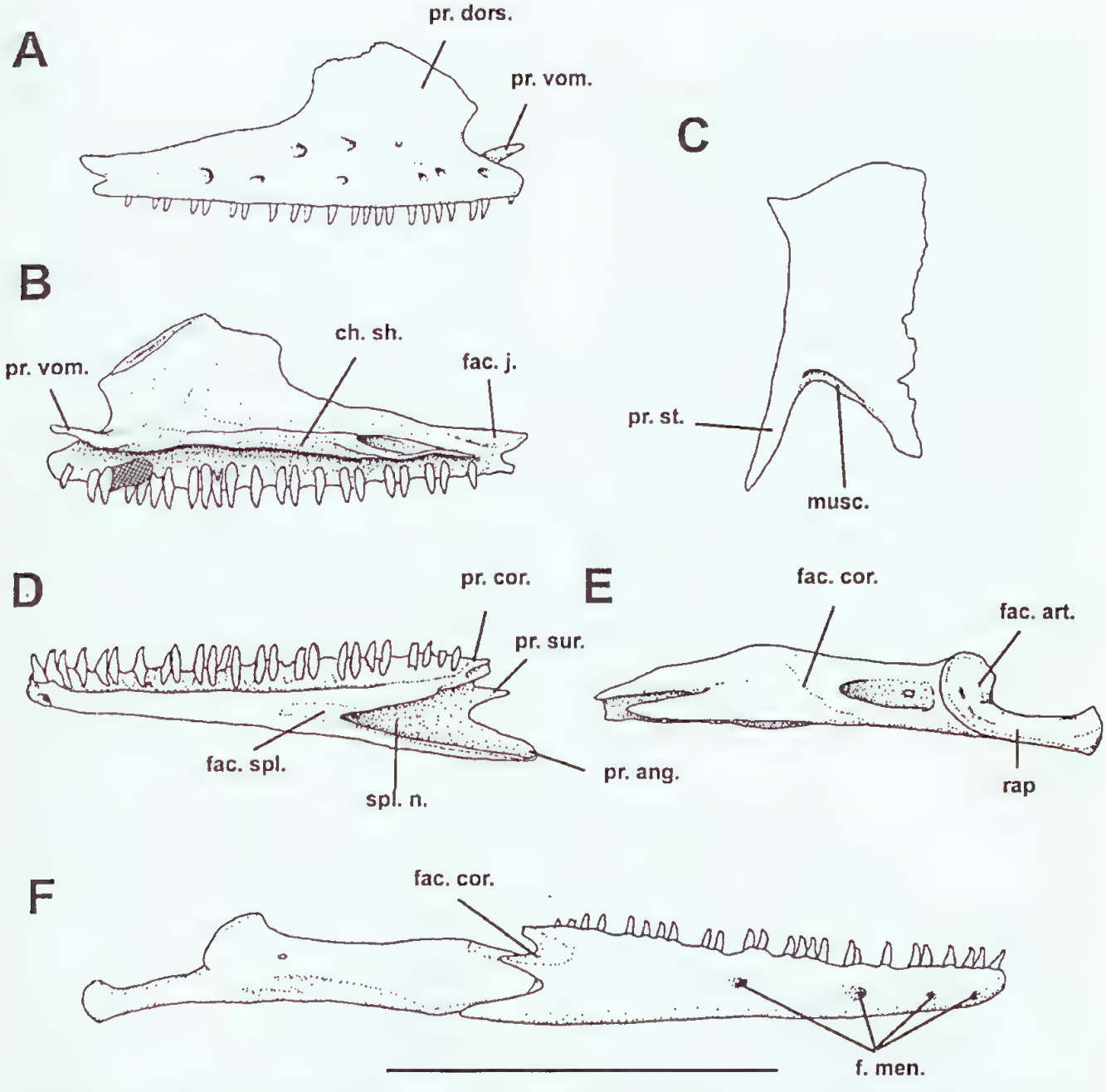

FIGURE 1. A–F *Diplodactylus cf steindachneri*. A, right maxilla (QM F30573) in lateral view and B, medial view. C, left parietal (QM F30574) in dorsal view. D–F right mandible (QM F30572). D, lingual view of dentary. E, lingual view of articular + surangular. F, articulated mandible in labial view. Abbreviations: ch. sh. – choanal shelf; f. men. – mental foramina; fac. art. – articular facet; fac. cor. – coronoid facet; fac. j. – jugal facet; fac. spl. – splenial facet; musc. – insertion point for dorsal neck musculature; pr. ang. – angular process; pr. cor. – coronoid process; pr. dors. – dorsal process; pr. st. – supratemporal process; pr. sur. – surangular process; pr. vom. – vomerine process; rap – retroarticular process; spl. n. – splenial notch. Scale bar = 5 mm.

Family GEKKONIDAE Gray, 1825

Subfamily DIPLODACTYLINAE Underwood, 1954

Diplodactylus Gray, 1825

Diplodactylus cf steindachneri
(Fig. 1A–F)

Material examined

Right maxilla (QM F30573); left parietal (QM F30574); partial right mandible (QM F30572), consisting of a dentary and fused surangular plus articular.

Description

Maxilla. The maxilla (QM F30573, Fig. 1A–B), a right element, is almost complete, with slight

erosion of the edges on the margin of the dorsal process. Total length 6.1 mm. A slender, dorsoventrally flattened vomerine process extends medially from the anteromedial end of the bone. The facial portion of the maxilla is gently arched along its dorsal margin. Although the dorsal margin is slightly damaged, there is no posterodorsally directed frontal process. The margin bordering the nasal opening is almost semicircular. The outer surface of the maxilla bears two series of foramina; one consisting of a row of six openings just above the teeth, the posteriormost the largest; and a second consisting of three relatively large openings at the level of the anteroventral corner of the orbit. The subocular ramus of the maxilla is robust and relatively short and deep. It does not taper to a point, as is usual in gekkonoids; the outline of the caudal extremity of the specimen is bifurcated, with the dorsal fork larger than the ventral. The internal surface of the maxilla bears a prominent choanal shelf, which is constricted at its mid-point and again anteriorly before projecting as the vomerine process. The inner face of the suborbital region has a small facet for a vestigial jugal on the dorsal fork, below which is a longer facet for the ectopterygoid.

There are 33 tooth loci, most with intact teeth. The teeth are small, cylindrical in section and tapering to acute points, with an apical cusp and lingual cusp separated by a narrow occlusal groove; this morphology is regarded as typical and plesiomorphic for gekkonids (Sumida & Murphy 1987). The individual teeth are uniform in size and vary only slightly in shape.

Parietal. The left parietal (QM F30574) (Fig. 1C) is complete except for slight erosion along the medial margin. In common with many living species, the medial edge of the bone may not have been fully ossified. Beginning at the bone's anteromedial apex, the anterior margin describes a shallow sinusoidal curve posterolaterally, terminating at the obtusely pointed apex of the articulation point with the postorbital. The caudal margin of the body of the parietal is almost straight-edged and faces caudolaterally. This margin bears a shallow caudally opening pocket, which would have been the insertion point for the superficial neck musculature. The supratemporal process is relatively slender and tapers to an acute point. Ventrally, the bone bears a descending flange parallel to the lateral margin, the flange descending to a pointed projection (epipterygoid process) about halfway along. Overall length of the specimen is 4.2 mm; width (measured at the apex of the postorbital articulation) 1.9 mm.

Adult mandible (QM F30572, Fig. 1D–F) is represented by a complete dentary and nearly complete compound bone consisting of the fused articular and surangular bones. The angular, splenial (or the composite angulosplenial typical of diplodactylines) and coronoid are absent.

Dentary. Total length (taken as a straight line from symphysis to tip of angular process) 6.5 mm. There are 36 teeth or tooth loci, the teeth being similar in size and shape to those on the maxilla, with the most anterior teeth having somewhat more recurved tips.

The dental sulcus is well defined by a lingual parapet that is evident as far as the posteriormost tooth. The posterior limit of the bone has three processes, which define two embayments. The uppermost (coronoid) process terminates just behind the last tooth and has facets on its lingual and labial aspects for the coronoid bone. The middle (surangular) and lower (angular) processes would have terminated at about the level of the apex of the dorsal process of the coronoid bone. The labial face bears four mental foramina, the posteriormost lying at the level of the 24th tooth. On the lingual face, the splenial notch extends forward to the level of the 27th tooth, and there is a facet extending anteriorly to the notch, suggesting that the splenial terminated at about the level of the 22nd tooth. There is no bony intramandibular septum exposed within the splenial notch.

Comparisons

The identification of these specimens as gekkonoids is based on several characters that are uniquely combined in this clade. The morphology of the articular and retroarticular region of the mandible shows an articular facet facing posterodorsally and the retroarticular process as slender and ventrally positioned. There is complete overgrowth by the dentary of the groove for Meckel's cartilage. The teeth are small, finely pointed and numerous. The parietal is poorly ossified, paired and lacks a pineal foramen. The elements are those of a small (approx 45 mm SVL) generalised gecko.

Studies of the phylogenetic relationships among the Gekkota (Bauer 1990; Donnellan et al 1999; Estes et al 1988; Kluge 1967a, 1967b, 1987) agree that the Australian region has three of the four major gekkotan lineages: the Gekkoninae, Diplodactylinae and Pygopodidae. The remaining gekkotan clade, the Eublepharidae, is found no

closer than Borneo (the genus *Aelurascalabotes*). To further establish the affinities of the Chinchilla specimens, we have noted several characters that appear to be useful in diagnosing membership of particular gekkotan lineages, based on the most commonly recovered elements: mandibles, maxillae, frontals and parietals.

Maxilla. The shape of the maxilla differs markedly between most gekkonines and the rest of the gekkotan lineages. Authors describing this area of the face generally emphasise bony contacts, using the dichotomy of either a prefrontal–nasal contact (shown by most diplodactylines) or a frontal–maxilla contact (shown by most gekkonines) (Fig. 2). In most Australian gekkonines (*Cyrtodactylus, Gehyra, Heteronotia, Nactus*), and in most other gekkonines examined, the maxilla arches posteromedially to contact the frontal, terminating in a frontal process that greatly reduces the exposure of the prefrontal and excludes the prefrontal from the nasal. In the remaining Australian gekkonine *Christinus* and in diplodactylines, the maxilla lacks this frontal process and the prefrontal includes an anteromedial process that contacts the nasal, usually excluding it from the maxilla. In eublepharids (*Aelurascalabotes* [Grismer 1988], *Hemitheconyx* [Rieppel 1984]) the prefrontals bear anteromedial processes but they are excluded from the maxilla due to well-developed anterolateral processes of the frontal; the maxilla is similar in shape to that of the diplodactylines. Pygopods are variable but most tend to show a gekkonine-like posterodorsal expansion of the maxilla to contact the frontal. The maxilla of the Chinchilla gecko has a low, gently arched dorsal process with no frontal process.

The Chinchilla fossil shows a distinctive feature of the maxilla that suggests a particular relationship within the Diplodactylinae. In lateral view its subocular ramus shows a relatively deep, bifurcate posterior termination, a characteristic also seen in a few species of the genus *Diplodactylus*. In these species the notched tip of the terminal portion of the maxilla is correlated

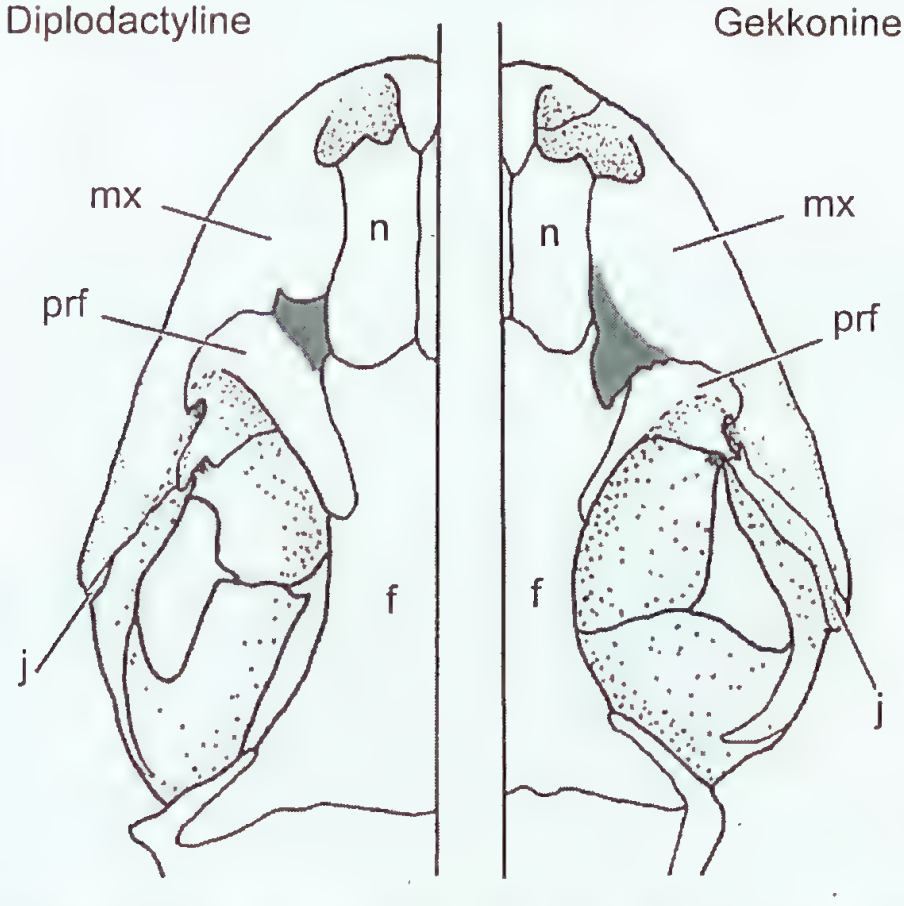

FIGURE 2. Comparison of the anterior part of the skull in a diplodactyline (*Diplodactylus stenodactylus*) and an Australian gekkonine (*Gehyra dubia*) gecko showing the usual patterns of contact between the frontal (f), nasal (n), maxilla (mx) and prefrontal (prf) bones. Areas in grey show the anteromedial (nasal) process of the prefrontal (diplodactyline), and the frontal process of the maxilla (gekkonine). *D. stenodactylus* also shows a vestigial jugal (j), compared with the usual degree of development of this bone in most other geckkotans as shown by *G. dubia*.

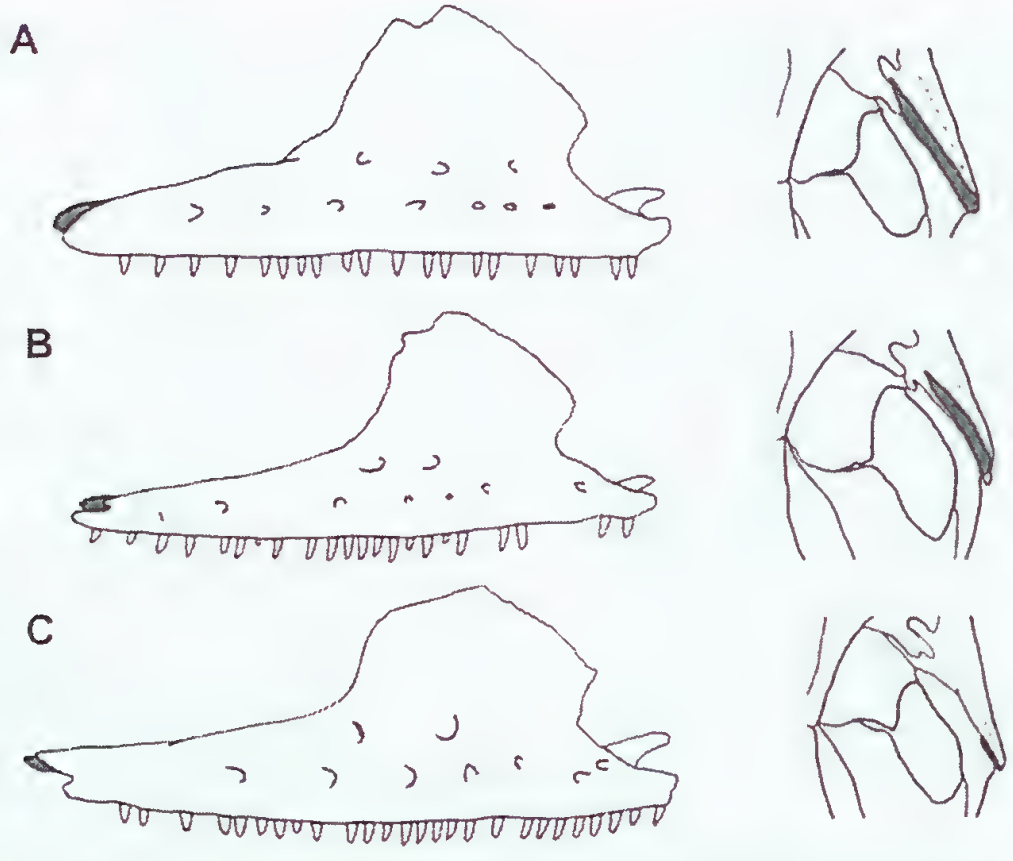

FIGURE 3. Right maxilla (slightly anterodorsal in aspect) and sketch of dorsal view of right orbit in three species of *Diplodactylus*, showing reduction of the jugal (grey), **A**, *D. granariensis* (R29135); **B**, *D. damaeus* (R24553); and **C**, *D. steindachneri* (R05153). Approx. length of maxillae 6–7 mm, not to scale.

with reduction of the jugal bone reported by Kluge (1967b). The two species reported as having the greatest reduction of the jugal (*D. steindachneri* and *D. stenodactylus*) have the most pronounced development of the bifurcate shape (Fig. 3A–C) and are essentially identical in appearance to the Chinchilla maxilla.

Frontal. No frontal has been recovered at Chinchilla, but future finds should be identifiable as gekkonine if there are three facets on its anterior portion (for the nasal, maxilla and prefrontal) or otherwise if there are only two facets. The relatively long nasal processes of eublepharid frontals might also be diagnostic for that clade.

Parietal. Many gekkotan taxa have distinctive parietal morphologies. However, this bone shows marked ontogenetic variation in its degree of ossification, the elaboration of muscle attachment points on its lateral and posterior margins, and the robustness of the supratemporal process. The most distinctive feature of the Chinchilla specimen is the concavity for the neck musculature on the posterior margin. This arrangement is not typical of most geckos, where the musculature simply attaches to the posterodorsal surface and edge of the parietal, or to the posteroventrally deflected trailing edge, generally with no more than a depression or a low ridge to mark the point of attachment. A more-or-less well-defined pocket is present in some members of the genus *Diplodactylus* (*D. stenodactylus*, *D. steindachneri*, *D. byrnei*, intraspecifically variable in *D. damaeus*) but is absent from other Diplodactylinae examined and was not seen in the gekkonines. Pygopod parietals are much slenderer than those of other gekkotans, the midline length being at least twice the width (cf less than 1.5 times the width).

Mandible. Some diplodactyline and gekkonine taxa as well as pygopods (Hutchinson 1997) have unique modifications of the mandible that are diagnostic for individual genera, but many gekkotan taxa have mandibles that are superficially similar in overall shape. In these generalised mandibles, the retroarticular process provides a key to the two major gecko subfamilies. In gekkonines, the retroarticular

process is generally spoon-like in shape, its dorsal surface forming an obvious, concave bowl. In most diplodactylines (*Saltuarius* and some *Strophurus* are exceptions) and in pygopodids, the retroarticular process is rod-like, with an oval, flattened or shallowly concave cross-section and terminated by a club. The morphology of the dorsal surface of the retroarticular process in eublepharids has not been described (published diagrams show only the shape in lateral or ventral view). The Chinchilla specimen has the clubbed, diplodactyline type of retroarticular process.

The fossil maxilla and mandible therefore not only show an overall similarity with diplodactylines, but also share several discrete character states that indicate specific diplodactyline affinities. The characteristics that distinguish the fossils are those that are uniquely combined in the genus *Diplodactylus*.

The Chinchilla fossils were found as disarticulated elements but their size and preservation, especially the mandible and maxilla, are consistent with having come from one animal. Based on the possession of a bifurcate terminus to the posterior ramus of the maxilla and the presence of a 'pocket' on the trailing edge of the parietal, they are referred to *D. steindachneri*. It is one of three species of *Diplodactylus* still found in the region (the other two are *D. vittatus* and *D. tessellatus*, Ingram & Raven 1991), and is the only one of these three species to have a vestigial jugal and bifurcate maxillary terminus. The other species with reduced jugals, members of the *D. stenodactylus* group, are found in the deserts of central and western Australia, the closest to Chinchilla being *D. immaculatus* of western Queensland.

Family SCINCIDAE Gray, 1825

Subfamily LYGOSOMINAE Mittleman, 1952

Tiliqua Gray, 1825

Tiliqua wilkinsonorum sp. nov.
(Fig. 4A–B)

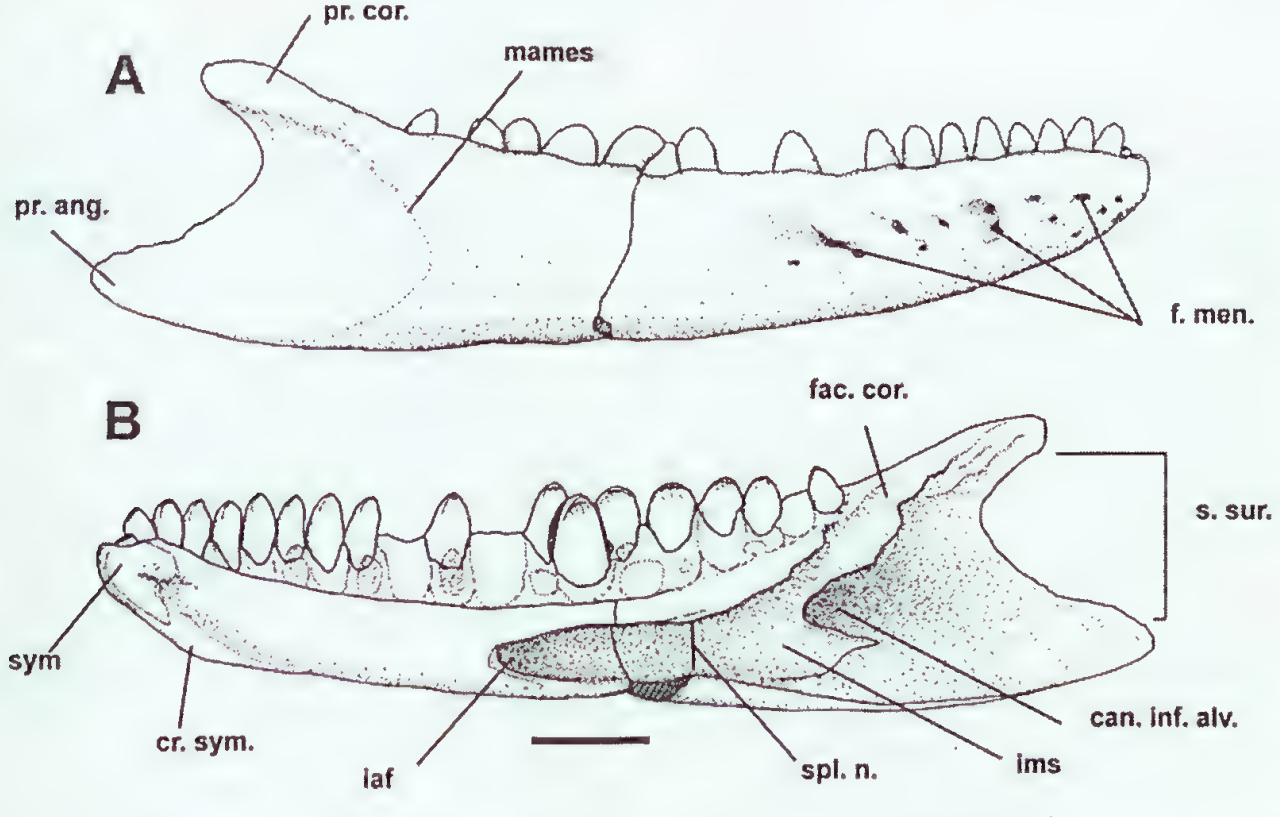

FIGURE 4. A–B *Tiliqua wilkinsonorum* n. sp. QM F30567 Holotype right dentary. A, labial; B, lingual. Abbreviations: can. inf. alv. – inferior alveolar canal; cr. sym. – symphysial crest; f. men. – mental foramina; fac. cor. – coronoid facet; iaf – inferior alveolar foramen (= anterior inferior alveolar foramen); ims – intramandibular septum; mames – limits of attachment for external adductor musculature; pr. ang. – angular process; pr. cor. – coronoid process; spl. n. – splenial notch; s. sur. – surangular suture; sym. – symphysis. Scale bar = 5 mm.

Material examined

Holotype: a right dentary (QM F30567).

Type Locality

Wilkinson's Quarry site, Chinchilla area, southeastern Queensland. The specimen comes from a fossil-bearing unit within the quarry that lies unconformably on top of a layer of fine sand. The sediments are primarily fluviatile in nature and represent a number of depositional events.

Age

Chinchilla Local Fauna, late Early to Middle Pliocene (Tedford et al 1992).

Diagnosis

A large species, dentary tooth row length 33 mm, differing from other *Tiliqua* by the following combination of characters: all tooth crowns pointed and retaining an occlusal ridge, the crown scarcely wider than the shaft; coronoid process of the dentary relatively slender, narrower than long, its shape correlated with a curved and concave, rather than angular or straight, dentary–surangular suture connecting the base of the coronoid process with the tip of the angular process.

Description

A right dentary, bearing a complete row of 20 teeth or tooth loci. The specimen is almost intact, being slightly damaged at the apex of the splenial notch and on the ventral edge adjacent to a repaired crack through the jaw at the level of the 15th tooth. Total length, from the anteriormost point of the symphysis to the tip of the angular process, 47.8 mm. Depth at level of 16th tooth (excluding tooth), 7.8 mm. Maximum depth of jaw, measured vertically from the apex of the coronoid process, 13.1 mm. Maximum width, measured in occlusal view at the level of the 16th tooth, 8.0 mm.

Meckelian groove closed, no trace of suture. A pronounced crest runs caudally from the symphysis along the ventrolingual margin of the jaw, gradually merging with the body of the dentary at about the level of the eighth tooth. Apex of the splenial notch at about the level of the 12th or 13th tooth, slight uncertainty due to the broken edge of the inferior alveolar foramen at the apex of the notch. Labial surface with pronounced, arcuate adductor muscle scar that has its apex level with the last tooth. Angular process projects 15 mm beyond the level of the last tooth. Dorsal margin of angular process merges with the ventral margin of the coronoid process along a smooth concave curve that has its apex at the level of the tooth row. Coronoid process well developed, flattened, but relatively small compared with other *Tiliqua*. A series of mental foramina starts at the level of the 11th tooth and runs anteriorly to the symphysis. These foramina are mostly arranged as a series of superposed pairs, with a total of about nine in the series.

Intramandibular septum fused ventrally along its length to the ventral lamina of the dentary, completely separating the inferior alveolar canal from the Meckelian canal. Caudal margin of intramandibular septum with a deep, curved notch, bounded ventrally by a caudally projecting prong.

Tooth row, in occlusal view, almost straight, gently curving medially anterior to the level of the sixth tooth. Labial wall of dental sulcus tall and robust. Lingual wall low but distinct anteriorly, reducing caudally and disappearing by about the level of the 16th tooth. Lingual face of dentary below the dental sulcus vertical, sharply distinct from the tooth row. Dentition pleurodont. The first of 20 teeth is broken off and the 10th, 12th and 19th loci are empty, but all other teeth are present and well preserved. The teeth vary distinctly in size, becoming larger progressing caudally, with the maximum reached in positions 13 to 16, the subsequent teeth then diminishing in size. As a guide to the changes in tooth size, tooth 6 is 3.5 mm high by 1.3 mm wide (measured normal to the lingual aspect) while tooth 14 is 4.3 mm high by 2.4 mm wide; thus, height increases by 23% and width by 85%. In lingual view, the tooth crowns are acutely pointed anteriorly, becoming obtusely pointed by about the 13th tooth. The crown of each tooth is margined by an occlusal ridge that separates its lingual and labial surfaces. In mesial view the tooth crowns have a parabolic curved outline labially, but the lingual surface is flatter, descending almost vertically from the apical ridge and forming an angular contact with the rounded labial surface. On the largest teeth, several low striae run vertically down from the apical ridge on both labial and lingual surfaces of the crown.

Comparisons

The combination of the closed Meckelian groove, enlarged 'cheek' teeth with more than one large tooth posterior to position 10, and an enlarged and flattened coronoid process is unique and diagnostic for the bluetongue lizards of the genus *Tiliqua* (Shea 1990). The related genus

Cyclodomorphus has only a single enlarged cheek tooth, while other lygosomines with a closed Meckelian groove lack such obvious dental differentiation.

Most species of *Tiliqua*, however, have a more specialised dentition than *T. wilkinsonorum*. The plesiomorphic tooth crown morphology in skinks includes a convex outer surface, curving occlusally to a pair of apical ridges separated by a groove (M. H. pers. obs.; Sumida & Murphy 1987), while the lingual surface is flattened and oriented almost vertically, forming an angular contact with the apical ridge. In lingual and mesial views the crown is acutely pointed. In contrast to this, species of *Cyclodomorphus* and *Tiliqua* have teeth modified for durophagy (Estes & Williams 1984). Most species of *Tiliqua*, including *T. gigas*, *T. multifasciata*, *T. occipitalis*, *T. pusilla*, *T. rugosa* and *T. scincoides*, have cheek teeth with expanded crowns, and have lost or greatly reduced the plesiomorphic asymmetry of the crown. In occlusal view the crown is circular in shape, and when viewed mesiodistally the crown profile, a convex curve, is similar in shape lingually and labially. The apex of the tooth has a central conical projection with pronounced striae radiating over the crown from this central point. Most individuals lack an occlusal ridge, although many *T. occipitalis* and some *T. rugosa* have a remnant on the tooth apex. *Tiliqua adelaidensis* has quite different dentition in which the enlarged cheek teeth are labiolingually compressed, with a pronounced cutting edge formed by the apical ridge. *Tiliqua nigrolutea* is the living species that shows the closest dental similarity to *T. wilkinsonorum*. The teeth show little expansion of the crowns, which are pointed and retain an obvious occlusal ridge that demarcates the crown into lingual and labial aspects. These two species show an asymmetric tooth crown profile in mesiodistal view, with a more steeply descending lingual surface. Compared with *T. nigrolutea*, the teeth of *T. wilkinsonorum* differ only in being more robust and having the crowns of the largest teeth more expanded and obtusely pointed. These differences could be attributed to allometry or individual variation in tooth proportions, which is considerable in living *Tiliqua* (M. H. pers. obs.). However, other characteristics of the fossil specimen differentiate it from both *T. nigrolutea* and other *Tiliqua* species.

The dentary is from a very large *Tiliqua*. Using the average ratio of tooth row to mandible length (0.48) that applies in extant *Tiliqua*, the tooth row length of *T. wilkinsonorum* of 33 mm extrapolates to an approximate mandible length of 68 mm. This size is approached only by the largest males of *T. rugosa* and *T. scincoides* (G. M. Shea pers. comm.) and suggests that *T. wilkinsonorum* may have had a snout-vent length close to 400 mm and a mass in excess of one kilogram. In spite of this size, the dentary of *T. wilkinsonorum* is notably gracile. This is most clearly seen in the shape of the coronoid process and the surangular suture running from the base of the coronoid process to the tip of the angular process. In all extant *Tiliqua*, the coronoid process is dorsally and caudally expanded. This expansion is masked to some extent because the base of the coronoid process is absorbed by caudal expansion of the trailing edge of the dentary such that the surangular suture is not deeply incised into the labial lamina of the dentary. The precise course of this suture varies both inter- and intraspecifically (Fig. 5A–I). In *T. nigrolutea*, *T. occipitalis* and *T. rugosa*, this suture usually runs vertically from the coronoid process and then angles caudoventrally to the tip of the angular process of the dentary. In *T. adelaidensis*, *T. gigas*, *T. multifasciata* and *T. scincoides*, the suture tends to run caudoventrally in an almost straight line from the base of the coronoid process. In none does it trace the excavated curve seen in *T. wilkinsonorum* (and other skinks). In *T. wilkinsonorum* the coronoid process is less expanded than in any extant species, with the possible exception of *T. gigas*, but is more clearly defined ventrally by the anterior sweep of the concave surangular suture. In living *Tiliqua* species, the expanded coronoid process and adjacent parts of the dentary increase the strength of this region of the mandible and increase the area of attachment for the jaw-closing tendon of the *m. adductor medius externus superficialis* (Haas 1973). The relative slenderness of the coronoid process and the concave surangular suture in *T. wilkinsonorum* are closer to the morphology seen in other skinks, including *Egernia*, the genus that probably includes the sister group of the *Tiliqua* lineage.

In summary, *T. wilkinsonorum* is one of the largest known specimens of *Tiliqua*, and has less specialised teeth than all but *T. nigrolutea* and a more slender (plesiomorphic) coronoid process of the dentary than all but *T. gigas*. The morphology of the teeth and the relative gracility of the caudal end of the dentary suggest that *T. wilkinsonorum* was not as specialised for durophagy as most other large *Tiliqua*.

Tiliqua wilkinsonorum is the third species of *Tiliqua* to be found in the Tertiary of Australia

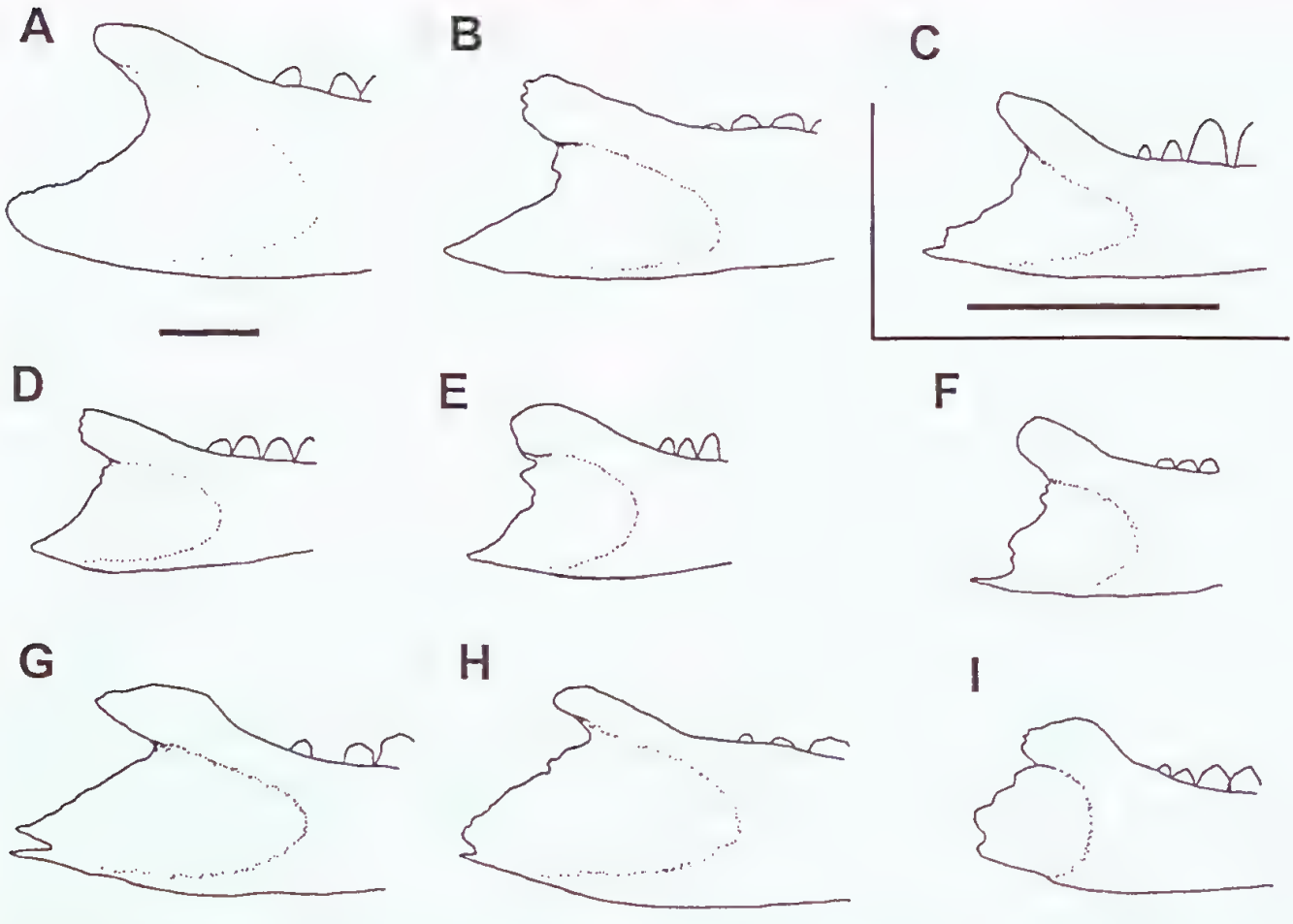

FIGURE 5. Dentary variation in *Tiliqua*. Detailed views showing variation evident in the degree of expansion of the coronoid process of the dentary and the shape of the dentary–surangular suture. All to same scale except *T. adelaidensis* (inset); both scale bars = 5 mm. **A**, *T. wilkinsonorum*. **B**, *T. rugosa* R27028. **C**, *T. adelaidensis* R40738. **D**, *T. nigrolutea* R02725. **E**, *T. nigrolutea* R47698. **F**, *T. occipitalis* R35758. **G**, *T. scincoides* R27039. **H**, *T. gigas* R11419. **I**, *T. multifasciata*, R35757.

and the second extinct species. Shea and Hutchinson (1992) described a very small species, *T. pusilla*, from the early Middle Miocene of Queensland, and specimens indistinguishable from a living species, *T. scincoides*, have been recorded from the Pliocene of South Australia (Pledge 1992) and Queensland (Mackness & Hutchinson 2000).

cf. *Cyclodomorphus* Fitzinger, 1843

Material examined

A partial dentary (QM F30568).

Description

The specimen represents about one-third of a left dentary, lacking the anterior portion, anterior to the last six teeth and lacking the coronoid and angular processes. It is not a juvenile, based on several cycles of tooth replacement being evident. The groove for the Meckelian cartilage is completely obliterated by the dentary. The third-last tooth is markedly enlarged. The tooth anterior to this is absent, but its locus is smaller, while the other remaining teeth are smaller again. A single large mental foramen is present on the labial surface of the jaw at the level of the fourth-last tooth. The teeth, both enlarged and small, have blunt, slightly laterally compressed crowns with virtually no apical ornamentation such as cusps, grooves or striae.

Comparison

The fossil appears to have only one markedly enlarged cheek tooth, with a second moderately enlarged tooth anterior to it. Among extant Australian skinks, only members of the *Tiliqua* lineage combine a closed Meckelian groove and enlarged durophagous cheek teeth (Shea 1990).

The dentitions of the two genera of this lineage, *Tiliqua* and *Cyclodomorphus,* differ in that adults of *Tiliqua* have several enlarged cheek teeth while those of *Cyclodomorphus* usually have only one strongly enlarged tooth. On this basis as well as its small size and overall shape, the Chinchilla specimen is more similar to *Cyclodomorphus* than it is to *Tiliqua.* However, *Tiliqua adelaidensis* and the extinct *T. pusilla* show that the small species of *Tiliqua* may have only two enlarged cheek teeth, so that the distinction on tooth pattern alone is not entirely conclusive. Other attributes distinguishing the two genera, including the shape of the symphysial region, are not preserved on the specimen. In the shape of the crowns and lack of occlusal striae, the fossil is unlike any species of either *Cyclodomorphus* or *Tiliqua* examined in this study, but it is too fragmentary to either allocate to a genus with certainty or to warrant description as a new taxon.

Family VARANIDAE Gray, 1827

?*Megalania* sp.

Material examined

Five isolated dorsal vertebrae (WPC 115, 116, 2409, 2014, 3322), three isolated dorsal fragments (WPC 2040, 3555, 3556), four isolated caudal vertebrae (WPC, 1429, 1573, 2364, 2524).

Characters

The genus *Megalania* is characterised in part by having massive thoracic and lumbar vertebrae with weakly developed zygosphenes (absent in typical *Varanus*) as well as small depressed neural canals. The adult teeth of *Megalania* are large and slightly recurved distally. The anterior cutting edge is rounded and serrated distally. The posterior cutting edge is thin, blade-like and serrated along its entire length (Hecht 1975).

Description

The dorsal vertebrae are much more massive than those of any extant varanid but compare well in morphology with those from an extant varanid *Varanus varius* (AR 7641) as well as from large fossil varanids from the Bluff Downs Local Fauna (Appendix 2; Tables 1 and 2). The Chinchilla specimens are 62% larger than those measurements supplied for Australia's largest extant varanid, the perentie *Varanus giganteus* by Smith (1976) and 20% larger than those for the large fossil varanid from Bluff Downs Local Fauna (Mackness & Hutchinson 2000).

Remarks

A single maxilla (QM F874) from the Chinchilla Sand was referred to *Varanus dirus* (Hecht 1975), a taxon originally described by De Vis (1889) on the basis of an isolated tooth from the Pleistocene Kings Creek locality. Hecht (1975) synonymised *V. dirus* with *Megalania prisca.* Four isolated vertebrae (two caudals and two dorsals) have also been collected from the Chinchilla Sand and, although Hecht (1975) referred them to *Megalania,* he also suggested that this material may represent a separate Pliocene species.

The assignment of the larger varanid vertebrae described in this paper to ?*Megalania* is done purely on the basis of convention. Opinion is divided as to the current status of the genus, with Hecht (1975) and Molnar (1990) concluding it is valid but Estes (1983) and Lee (1996) suggesting that *Megalania* should be synonymised with *Varanus.* A large collection of varanid fossils from Pliocene localities is presently under study by the authors.

Varanus sp.

Material examined

Two isolated dorsal vertebrae (WPC 118, 1430), one isolated caudal vertebra (WPC 3557).

Characters

These vertebrae are identified as varanid by their distinctive condyle–cotyle articulations. The dorsal vertebrae also show the characteristic constriction of the centra anterior to the condyle seen in *Varanus.*

Description

The vertebrae show characteristic varanid morphology with a range of centra lengths (Appendix 2; Table 3) that indicate a medium-sized goanna of the size of *Varanus gouldii.*

Remarks

Although Wilkinson (1995) suggests some characters for separating varanid species on the basis of vertebral morphology, many of these rely on the neural spine being present. This feature is missing on all three fossil vertebrae. Interspecific and/or intraspecific variation in varanid vertebrae have yet to be fully tested; therefore, characters

identified by Wilkinson (1995) must be used with caution.

Discussion

The composition of the lizard fauna from the Chinchilla Sand Local Fauna, at least at family level (Appendix 2; Table 4), is similar to that of the Bluff Downs Local Fauna. This is the only other Australian Pliocene locality with a significant lizard record (Mackness & Hutchinson 2000). It differs from Bluff Downs in the generic representatives of each family, but the significance of this is unknown; it could merely be stochastic, reflecting the very small sample sizes at each locality. The palaeoenvironment was primarily fluviatile for Chinchilla and lacustrine and fluviatile for Bluff Downs.

The exact nature of the Chinchilla palaeoecology has yet to be determined. While there may have been a significant wetland component, as suggested by the presence of various aquatic taxa such as turtles (Gaffney 1981; Gaffney & Bartholomai 1979) and waterbirds (Olson 1975, 1977), there is also evidence that the environment was highly seasonal (Mackness et al 1999; Wroe & Mackness 2000). The presence of arboreal species such as *Koobor* (Archer 1977) and an unnamed phascolarctomorph (Mackness et al 1994) would be consistent with a complex and mature forest, but the composition of the mammalian fauna indicates a lack of undoubted closed-forest species. Further, the predominance of grazing kangaroos and diprotodontids suggests that grasslands were also part of the environment.

The presence of an extinct reptile species at Chinchilla is noteworthy given the slow rate of faunal turnover in reptile populations (La Duke 1991). *Tiliqua wilkinsonorum* represents a distinctive but extinct species of lizard, a relatively uncommon observation for the Pliocene (Estes 1983). A conclusion that can be drawn from the presence of such 'fossil endemics' is that they signal ecological or geographical factors at Chinchilla during the Pliocene that are no longer present in recent environments.

Acknowledgments

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APPENDIX 1

Osteological material used for comparisons. Specimens are from the Herpetology Section of the South Australian Museum and the Western Australian Museum (WAM prefix).

Gekkonines

Christinus marmoratus (R35562; R39934), *Cosymbotus platyurus* (R36789), *Cyrtodactylus louisiadensis* (R14002), *Gehyra australis* (R34136), *G. dubia* (R42872), *G.* sp. (2n = 44) (R44595), *G. catenata* (R35561), *G. oceanica* (R08687), *G. purpurascens* (R36377), *G. robusta* (R34222), *Gekko gecko* (R35559), *G. japonicus* (R07435), *G. vittatus* (R55978) *Gonatodes humeralis* (R40088), *Gymnodactylus darwinii* (R40090), *Hemidactylus frenatus* (R35564), *Heteronotia binoei* (R09751 A, R33565, R39935), *Nactus cheverti* (R09740 B), *Paroedura picta* (R55105), *Phelsuma madagascariensis* (R40025), *Ptyodactylus hasselquisti* (R49804), *Tarentola annularis* (R40024), *Thecadactylus rapicauda* (R40099–100).

Diplodactylines

Bavayia ornata (R06752), *Crenadactylus ocellatus* (R03113 C), *Diplodactylus byrnei* (R13514), *D. conspicillatus* (R19967), *D. damaeus* (R20017, R24553) *D. 'granariensis'* (SA populations) (R02010, R26494, R29135), *D. immaculatus* (R42676), *D. pulcher* (R26383), D. *steindachneri* (R05153, R52746), *D. stenodactylus* (R07592, R21240, R26777), *D. tessellatus* (R03876, R40938), *D. vittatus* (R35568), *Hoplodactylus pacificus* (R11025), *Nephurus asper* (R35567), *N. laevissimus* (R14987 A), *N. levis* (R00309 A, R27044–45), *N. milii* (R55422, R57083), *N. stellatus* (R32297), *Oedura lesueurii* (R33597), *O. marmorata* (R42893), *O. monilis* (R35563), *O. tryoni* (R33583), *Phyllurus platurus* (R35054), *Rhynchoedura ornata* (R35827), *Saltuarius swaini* (R29205), *Strophurus ciliaris* (R10697, R35566), *S. intermedius* (R14325 C).

A range of pygopod skulls was also examined (see Hutchinson 1997 for listing).

Egernia group skinks

Corucia zebrata (R35765), *Cyclodomorphus maximus* (WAM R77193, WAM R77637), *C. michaeli* (R35682), *C. gerrardii* (R35761, R47699), *C. melanops elongatus* (R03231, R03856 G, R35681), *C. venustus* (R38021), *Egernia coventryi* (R35686, R47693–94), *E. cunninghami* (R35680, R35763), *E. depressa* (R03433 H), *E. formosa* (WAM R65803), *E. hosmeri* (R22510), *E. inornata* (R07234, R07238, R07245 A, R35687), *E. kingii* (WAM R36376, WAM R89269–70), *E. luctuosa* (WAM R36019), *E. major* (R27043, R35762), *E. multiscutata* (R08469, R25245), *E. napoleonis* (R35692, R51076, WAM R45350), *E. pilbarensis* (WAM R78945), *E. pulchra* (R40026, WAM R71884), *E. richardi* (R10841), *E. saxatilis intermedia* (R43961), *E. stokesii* (R02560, R41913), *E. striata* (R07179, R07198), *E. striolata* (R02909 B, R16593, R26891, R38019), *E. whitii* (R02726, R35690, R27042, R35689, R45316, R34886, R35688, R35691), *Tiliqua adelaidensis* (R40738, R40745, R43412), *T. gigas* (R11419), *T. multifasciata* (R27041, R35757), *T. nigrolutea* (R02725, R27048, R27050, R47698), *T. occipitalis* (R02724, R25369, R27047, R35758), *T. rugosa* (R02563[2], R02564, R27026, R27028, R02801, R25615, R27027, R27029, R27584, R31855, R35760), *T. scincoides* (R02561, R27036–40, R35759, R38020, R43962, R27094).

APPENDIX 2

TABLE 1. Measurements (mm) of ?*Megalania* dorsal vertebrae from Bluff Downs and Chinchilla Local Faunas compared with *Varanus giganteus*. Measurements as defined in Methods. Range (mean ± standard deviation). Data for *V. giganteus* taken from Smith (1976), for Bluff Downs from Mackness & Hutchinson (2000).

Specimen	No	Pr-Po	BW/Pr-Po	CW/Pr-Po	Pr-Pr/Pr-Po
V. giganteus	20	24.5–27.1 (25.7±0.14)	0.54–0.64 (0.58±.005)	0.55–0.63 (0.59±.006)	0.88–1.01(0.92±.007)
Bluff Downs	7	24.5–27.1 (25.7±0.14)	0.54–0.64 (0.58±.005)	0.55–0.63 (0.59±.006)	0.88–1.01(0.92±.007)
Chinchilla	4	24.5–27.1 (25.7±0.14)	0.54–0.64 (0.58±.005)	0.55–0.63 (0.59±.006)	0.88–1.01(0.92±.007)

TABLE 2. Measurements (mm) of individual ?*Megalania* vertebrae. Measurements as defined in Methods.

Specimen	Pr-Po	Pr-Pr	Po-Po	BW	CW	COW	CEL
WPC116	39.4	33.2	39.3	20.5	26.1	27.6	25.0
WPC2014	38.9	46.4	41.4	–	–	30.4	–
WPC2409	48.3	57.3	49.5	26.4	29.4	31.6	28.2
WPC3322	37.2	43.5	40.4	17.6	23.2	25.2	26.4
WPC3555	56.8	–	–	–	–	–	–
WPC3556	44.3	–	–	–	–	–	–
(Mean/SD)	(41.6 ± 6.6)	(47.6 ± 6.6)	42.6 ± 4.6)	(21.5 ± 4.5)	(26.2 ± 3.1)	(28.7 ± 2.9)	(26.5 ± 1.6)

TABLE 3. Measurements (mm) of centra of dorsal vertebra of fossil *Varanus* sp. from Chinchilla Local Fauna (WPC), Bluff Downs Local Fauna (QMF) and extant *Varanus varius* (AR7641).

Specimen	Measurement	Specimen	Measurement
WPC118	12.2	AR7641 (a)	15.3
WPC1430	16.5	AR7641 (b)	15.3
QM F7774	14.2	AR7641 (c)	15.4
QM F23238	10.5	AR7641 (d)	15.4
QM F23659	10.8	AR7641 (e)	15.6
QM F23683	13.8	AR7641 (f)	15.7

TABLE 4. Comparison of lizard taxa recovered from the Queensland Pliocene (Chinchilla and Bluff Downs Local Faunas. Source: Mackness & Hutchinson 2000). Code: present •, absent ×, endemic form [e].

Taxa	Chinchilla	Bluff Downs
Gekkonidae		
cf *Heteronotia*	×	•
Diplodactylus	• [e]	×
Agamidae		
unidentified material	•	•
Varanidae		
?*Megalania*	•	•
Varanus	•	•
Scincidae		
Tiliqua	• [e]	•
Cyclodomorphus	•	×
Egernia	×	•
Eulamprus	×	•

FIRST REPORT OF CUPRESSACEAN CONES IN THE EOCENE EYRE FORMATION OF SOUTH AUSTRALIA

NS PLEDGE

PLEDGE, NS. 2002. First report of cupressacean cones in the Eocene Eyre Formation of South Australia. *Records of the South Australian Museum* **35**(2): 185–191.

Conifer impressions are a very minor component in the various 'silcrete flora' assemblages found in the interior of South Australia. Previously, no fruiting bodies had been found, although numerous foliage species had been recognised. This note describes impressions of the first woody ovulate cones found, discovered in a small block of silicified sandstone near Lake Hart, west of Woomera. They are distinctive and do not appear to bear close affinity to any modern Australian species, but resemble cones of the African *Widdringtonia*.

NS Pledge, South Australian Museum, North Terrace, Adelaide, South Australia 5000. Manuscript received 19 April 2002.

Besides *Athrotaxis*, the modern Australian flora contains three genera of cupressacean conifers: *Callitris*, *Actinostrobus* and *Diselma*. Recent morphological and molecular work by Gadek et al (2000) shows that the latter are closely related to an African genus *Widdringtonia*, within a monophyletic group, the subfamily Callitroideae, comprising all Southern Hemisphere cupressaceans except *Athrotaxis*.

Fossil conifers, including members of the Cupressaceae, are sparse in the Australian fossil record (Hill & Carpenter 1989). Many reported specimens have occurred as impressions in fine-grained sediments, with consequent difficulty in interpreting fine structure, but organic remains also occur, eg in Tasmania, and have yielded valuable material (ibid). This has more than doubled the number of genera in the Australasian region, with taxa that occur today in New Guinea, New Zealand and elsewhere, as well as several extinct genera (Hill & Brodribb 1999).

Plant impressions in silicified sandstone have been known from the Woomera area / Arcoona Plateau for many years (Chapman 1937), and as far as Stuart Creek to the north and Clayton Station on the Birdsville Track to the northeast. Most of the moulds are of angiosperm leaves (Rowett 1997), a few of which have been described (Chapman 1937; Greenwood et al 2001). Conifer vegetative shoots are a minor unobtrusive component, studied by Nunn (1964) and Offler (1969, 1984). In the 1970s localities were found yielding natural moulds of fruiting bodies, mostly of myrtaceous origin (Ambrose et al 1979; Lange 1978). A few specimens referable to fruit of Proteaceae (*Banksia* sp.) and Casuarinaceae have been noted (Greenwood et al 2001; this writer, unpubl.) but, until now, no coniferous cones have been recognised, despite the widespread occurrence of vegetative shoots. Nunn (1964) recognised 21 different conifer morphotypes, some of which could be related to modern species from the Australasian region. She stressed the problems and uncertainties of identifying the species.

These plant fossil impressions occur in a number of isolated, discrete localities over an area of thousands of square kilometres, often in apparent channel deposits, eg at Nurrungar, Island Lagoon, near Woomera (pers. obs. 1969), in what has been regarded as Eyre Formation s.l. Their age has long been in dispute (Ambrose et al 1979; Callen & Lange 1986; Chapman 1937; Greenwood et al 1990; Wopfner et al 1974) but recent discoveries at Nelly Creek, Lake Eyre South, have at last related them to deposits datable by palynological studies to the middle Eocene (Alley et al 1996; Callen & Cowley 1995; Christophel et al 1992) within the Eyre Formation. Variations in the contained fossil floral assemblages suggest that the different localities probably have slightly different ages.

Material and Methods

In 1979 members of the Woomera Natural History Society discovered plant impressions near

FIGURE 1. Locality map, Lake Hart and other 'silcrete flora' localities in South Australia.

Lake Hart in the Woomera Prohibited Area (Fig. 1). Subsequently, L. Marsh and T. Nurenberg presented a slab of quartzite to the South Australian Museum (SAM P22732; Fig. 2) bearing the impressions of a few leaves and seven fruit-like bodies. Silicone rubber casts (Fig. 3) taken from these moulds disclosed fruits strongly reminiscent of *Callitris* ovulate cones. Closer examination, however, showed that, instead of the six subequal valve scales (2 triplets) seen in *Callitris*, these fruit had two unequal pairs of valves (Fig. 4). Re-examination of the collection of silcrete flora material in the Museum failed to uncover any further specimens; SAM P22732 is therefore unique.

Comparison was made with dried specimens in the South Australian State Herbarium and with trees growing at the Mount Lofty Botanic Gardens.

Description

Order CONIFERALES

Family CUPRESSACEAE Neger

Genus *Incertae sedis*

The cones are globose to ellipsoidal in shape, with a slightly conical distal apex. The ellipsoidal shape may be due to slight compression during burial, but the flattening is always the same relative to the smaller valve scales and symmetry of the cone, and compression is therefore an unlikely cause. Dimensions vary from about 17 mm diameter and a length of up to 22 mm for the globose forms, to 15–22 mm diameter x 20 mm in length for the ellipsoidal specimens. In apical view the pair of larger valves are at the ends of the apparent ellipse. The smaller, narrower, valves meet apically along a contact line of about 5 mm, thus separating the pair of larger valves (Fig. 4). Although apparently mature, the cones have a relatively smooth surface, with none of the roughness that characterises the opened cones of many *Callitris* species. However, one cone, at least, shows slight apically convergent ribs on the valves. This is reflected in an impression of what appears to be a decorticated cone (Fig. 3), having exposed ribs that have the same symmetry and relationships as the valves. None of the fruits has split to release its seeds, so the extent of the sutures separating the valves may not be fully expressed. Nevertheless, the sutures extend slightly more than halfway towards the base. The valves each have a near-apical, small (roughly 1 mm), circular to elliptical scar, arranged symmetrically on the fruit (Fig. 4). The origin or purpose of these scars is unclear, although they are in the same position as the 'spurs' on the valves of some species of *Callitris* (Baker & Smith 1910: 47) and species of *Papuacedrus*, *Widdringtonia* and *Tetraclinis* (pers. obs.; Hill & Carpenter 1989; McIver 2001). The base and attachment are seen in one specimen, showing a petiole expanding gradually to about 5 mm diameter at its junction with the fruit, where there is an expanded leaf scale below the smaller valve (Fig. 4). Another specimen seems to show a 7–8 mm diameter subcircular scar on the base, where the stem attached.

Comparisons

Initial comparisons were with species of *Callitris*. The obvious difference is in the number

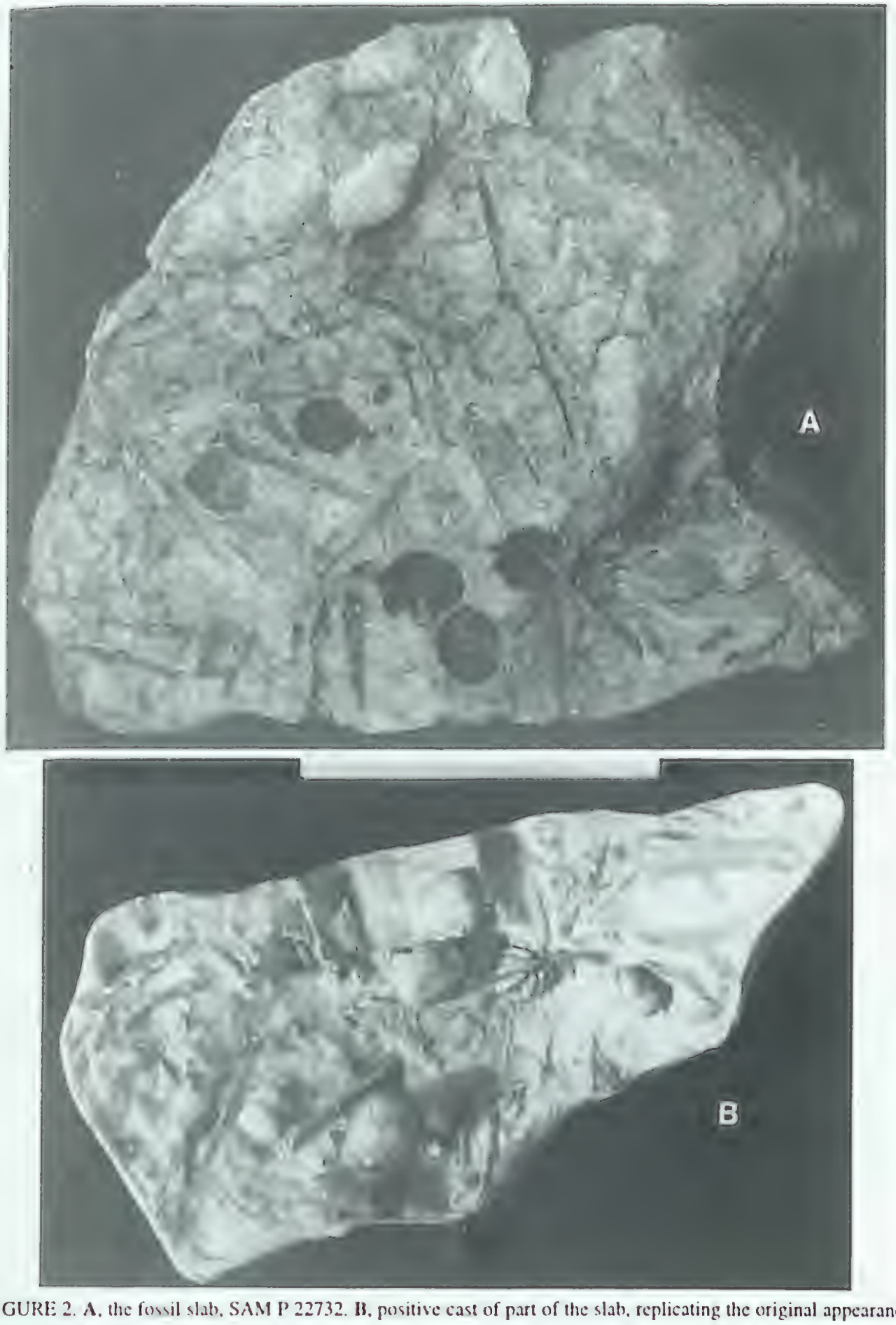

FIGURE 2. A, the fossil slab, SAM P 22732. B, positive cast of part of the slab, replicating the original appearance of the leaf litter at the time of burial. Scale in mm.

of valves in the cones, *Callitris* having three large valves alternating with three smaller ones, all ending acutely. Amongst living Australian conifers, there is only one species having two pairs of valves in the same decussate geometry as the fossils: *Diselma archeri* from Tasmania. However, its ovulate cones are tiny, barely larger in diameter than the shoots they terminate (pers. obs.). The living *Papuacedrus* from the island of New Guinea also has two pairs of valves, but its cones too are small and conical (Hill & Carpenter 1989).

A passing note in Baker and Smith (1910) directed attention to several non-Australian genera. *Diselma* had once been synonymised with *Fitzroya* from Chile and Patagonia, just as *Callitris* had been joined with *Tetraclinis* from Mediterranean North Africa and *Widdringtonia*

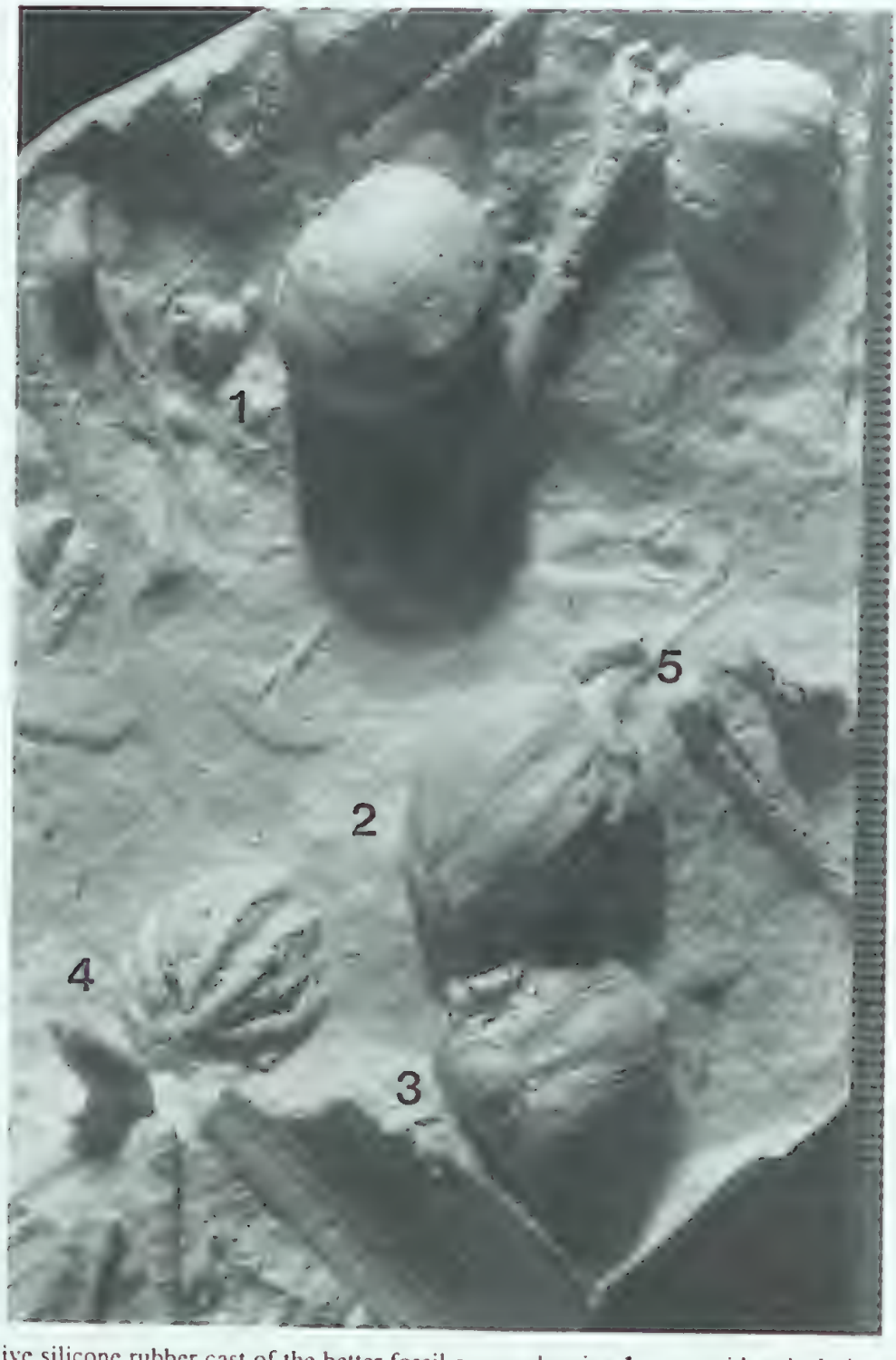

FIGURE 3. Positive silicone rubber cast of the better fossil cones, showing **1**, cone with apical view of sutures and valves with terminal scars; **2**, cone with attached stem and basal leaf-scale; **3**, cone with basal attachment scar; **4**, a decorticated cone; **5**, foliage fragment. Scale in mm.

spp. from southern Africa. I was not able to see fruits of *Fitzroya*, but am informed that they are nothing like the fossils (R. Hill, pers. comm., July 2002). Through the help of Ms H. Vonow at the South Australian Herbarium, I examined dry specimens of *Diselma archeri*, *Tetraclinis articulata*, *Widdringtonia cupressoides*, *W. whytei* and others and *Papuacedrus papuana*, and living *Widdringtonia* spp. in the Mount Lofty Botanic Gardens. There is an obvious similarity between these species and the fossil cones in the number and symmetry of the valves. However, *Tetraclinis* can be removed from consideration on the basis of two characters: the spurs near the tips of its valves are quite enlarged, particularly on immature cones (there is obviously some allometric growth involved here), and the foliage structure is quite different from the fossil shoot associated with the cones. Offler (1969) indicates that *Papuacedrus* foliage is widely represented in her material, and

FIGURE 4. Detail of cones; silicone rubber cast, showing **1**, cone with apical view of sutures and valves with terminal scars, **2**, cone with attached stem and basal leaf-scale, **3**, cone with basal attachment scar, **4**, foliage fragment.

it has been recognised in the Eyre Formation of the Poole Creek Palaeochannel near Lake Eyre South (Alley & Pledge 2000: 69). Fossil foliage has also been recorded from various Oligocene and Miocene sites in Tasmania (Hill & Brodribb 1999; Hill & Carpenter 1989). However, *Papuacedrus* differs considerably from the fossils in the tear-drop shape and small size of the cones, and in the presence of bract-like appendages halfway up each cone scale (Hill & Carpenter 1989).

There are two genera considered closely related to *Papuacedrus*, namely *Libocedrus* from New Zealand and New Caledonia, and fossil in Tasmania, and *Austrocedrus* from South America and also fossil in Tasmania (Hill & Carpenter 1989). They have ovulate cones of the same order of size as *Papuacedrus* (and therefore are much smaller than the Lake Hart fossils) but are similar in having a structure subapically on the abaxial surface of each cone scale: a spine in the case of *Libocedrus* and a minute tubercle in *Austrocedrus* (ibid). However, the cone scales of *Austrocedrus* are all apically acute with none truncated; therefore, that genus can probably be ruled out of contention.

The woody ovulate cones of the *Widdringtonia* spp. vary between species in both size and morphology. Like the fossils, they have two unequal pairs of valve scales, the upper pair having truncated apices that therefore meet along a contact of several millimetres. Of those examined, cones of *W. cupressoides* (Fig. 5) resemble the fossils most closely, although they tend to be smaller and have more prominent spurs on the valves, and the overall shape is more tulip-like, with a depressed base. Other species show a rougher, more rugose and warty or tuberculose surface on the valves than do the fossils, but this may be a reflection of the maturity of the fruit. The Lake Hart fossils differ markedly from the North American Cretaceous species *Widdringtonia americana* (McIver 2001), primarily in the development of a prominent umbo or boss on each valve scale in the latter species.

The vegetative shoot (Figs 3, 4) associated with the fossil cones is poorly preserved (the grain-size of the sediment approaching that of the smaller features), and cannot be guaranteed to relate to the cones. It seems to have the same square cross-section and short decussate, scale-like leaves as *Diselma archeri* (Clifford & Constantine 1980). This is unlike *Widdringtonia cupressoides*, which has shoots of rounder cross-section and longer decussate leaves. The leaves are apparently arranged in opposite pairs, as in *Libocedrus* and

FIGURE 5. Female cones of *Widdringtonia cupressoides* (L.) Endlicher, specimens from the South Australian Herbarium collections.

Papuacedrus (Hill & Carpenter 1989). Unfortunately, no other specimens from this site are available to support or deny this association, and the locality has reportedly been stripped by commercial interests for decorative stone.

Conclusions

It is apparent that these impressions represent the fruiting bodies of a previously unknown Australian species of conifer, and it is suggested that this shows closest affinities with species of *Widdringtonia*, *Diselma* and *Papuacedrus*. Without corroborative evidence in the form of organically associated foliage and pollen, it is not possible to specify which taxon the cones represent; no identification is proposed, but it could be a new extinct genus. *Widdringtonia* today inhabits seasonally dry to semi-arid regions of southern Africa (Hill & Brodribb 1999), as do *Callitris* spp. Such an environment is implied (Alley et al 1996) for part of the Eyre Formation. In view of the fact that Offler (1969) found no

trace of either *Callitris* or *Actinostrobus* foliage in the 'silcrete flora' of the Woomera area, that no cones of *Callitris* have subsequently been found in the large collections made since her study, and that there have been only a few finds of fossil *Callitris* foliage in southeastern Australia (Hill & Brodribb 1999), it is suggested that these typical Australian genera evolved subsequently, possibly from a form like the fossil taxon described here.

Acknowledgments

I thank Ms L Marsh and Mr T Nurenberg for donating the specimen to the South Australian Museum; Ms H Vonow, South Australian Herbarium, who assisted with access to preserved dry conifer specimens; and Prof. R Hill and a reviewer who read an early draft and provided some very useful references.

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DESCRIPTIONS OF A NEW GENUS AND TWO NEW SPECIES OF VIVIPARID SNAILS (MOLLUSCA: GASTROPODA: VIVIPARIDAE) FROM THE EARLY CRETACEOUS (MIDDLE–LATE ALBIAN) GRIMAN CREEK FORMATION OF LIGHTNING RIDGE, NORTHERN NEW SOUTH WALES

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HAMILTON-BRUCE, RJ, SMITH, BJ & GOWLETT-HOLMES, KL. 2002. Descriptions of a new genus and two new species of viviparid snails (Mollusca: Gastropoda: Viviparidae) from the Early Cretaceous (middle–late Albian) Griman Creek Formation of Lightning Ridge, northern New South Wales. *Records of the South Australian Museum* 35(2): 193–203.

Fossil gastropods belonging to the family Viviparidae (Caenogastropoda (Prosobranchia)) are described from the Early Cretaceous (middle–late Albian) Griman Creek Formation of Lightning Ridge, northern New South Wales. From our research, this is the earliest definitive record of non-marine gastropods from Australia and amongst the oldest viviparid material in the world recorded to date. A new genus and two new species are described, and other material attributable to the extant genus *Notopala* is recorded. Implications for the current distribution of the Viviparidae are addressed.

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Opalised fossils have long been known from the Lower Cretaceous (middle–late Albian) freshwater deposits of the Griman Creek Formation, Lightning Ridge, New South Wales (Smith 1999). To date, much of the published work has focused on fish (Kemp 1991; Kemp & Molnar 1981) and terrestrial tetrapod remains (Archer et al 1985; Flannery et al 1995; Molnar 1980a, 1980b, 1991; Molnar & Galton 1986; Rich et al 1989) with relatively few reports (Dettman et al 1992; McMichael 1957; Smith 1999) summarising the vast quantities of invertebrate material recovered from the area. The recent opportunity to examine Lightning Ridge gastropod specimens (brought to our attention by Ben Kear, South Australian Museum, as part of an ongoing assessment of vertebrate and invertebrate fossil material from the locality) from the collections of the Australian Museum, Sydney, and several private individuals has prompted a systematic appraisal of the gastropods within the material recovered. This study describes specimens attributable to the family Viviparidae (Caenogastropoda (= Prosobranchia)), including a new genus and two new species. Indeterminate material belonging to the extant genus *Notopala* is also recorded, and the implications for distribution of extant viviparid taxa are discussed.

The Viviparidae is a cosmopolitan group of freshwater caenogastropods, characterised by medium- to large-sized turbiniform shells which possess a rounded body whorl; moderately high, pointed spire; wide, round aperture; and sub-spiral, horny operculum (Smith 1992). The current Australian distribution of the group is limited to a few species occurring in the large drainage basins that span much of the arid centre and northern tropical regions of the continent.

The fossil record for Viviparidae is known from the Jurassic to Recent (*Viviparus* Montfort, 1810), with a tentative report based on an internal shell (?*Bernicia* Cox, 1927) mould (possibly of marine origin) from the Lower Carboniferous of England (Brookes-Knight et al 1960). Within Australia there are few records of fossil viviparids. Etheridge (1902) described the earliest potential Australian taxon, *Viviparus* (?) *alba-scopularis* Etheridge (also noted by Newton (1915)) from the Aptian marine deposits of the Doncaster Member (Wallumbilla Formation *sensu* Burton & Mason 1998), White Cliffs, New South Wales. This specimen is currently under examination by the authors and at present is regarded as being of unclear viviparid affinity. Cotton (1935a) erected

a species of *Notopala* (*N. wanjacalda*) from late Pleistocene sediments along the Murray River near Sunnyside, South Australia, and also noted a second taxon (*Notopala* sp.) from the same deposits, which showed strong similarity to the extant *N. hanleyi* (Frauenfeld, 1862). Viviparid snail shells from Early Cretaceous deposits in the Lightning Ridge area were recorded but not described by Dettman et al (1992) and Smith (1999); the latter also recorded possible representatives of the Naticidae, Thiaridae and Ellobiidae. Few other Australian non-marine gastropod fossils (all of Tertiary age) have been recorded (Archer et al 1994; Arena, 1997; Chapman 1937; McMichael 1968).

Materials and Methods

All specimens described herein are derived from the Lightning Ridge opal fields (exact mine localities from which these specimens originated are unknown), Surat Basin, northwestern New South Wales. The opal-bearing sediments in this area form part of the Griman Creek Formation, a unit dated as middle–late Albian in age (Dettman et al 1992). The deposit predominantly reflects a coastal plain facies (Burger 1988; Dettman et al 1992) situated in an Early Cretaceous high latitude zone (~70° S, Embleton 1984). Invertebrate fossils, plant root impressions and vertebrate taphonomy suggest a freshwater estuarine to lacustrine setting (Dettman et al 1992; Molnar 1980a). Palaeoclimatic indicators imply strongly seasonal conditions with sea-level isotopic palaeotemperatures in the Eromanga Basin / Surat Basin regions ranging from 11.9°C (northeast) to 16.3°C (southwest) (Dettman et al 1992; Stevens & Clayton 1971).

Designation of parietal fold position on the specimens was achieved by positioning the fold within the aperture on a 360° compass setting when a vertical line through the axis, juxtaposed to the column, is intersected by a horizontal line corresponding to the midpoint of the aperture. The adapical axis above the point of intersection is taken as zero degrees. The diameters of all shells were measured following the method of Boycott (1928) and are defined as 'the greatest dimension that can be found starting with the edge of the lip to a point on the opposite side of the shell on the last whorl'. To enable extrapolation of the numbers of missing whorls, the incremental angle of the shells was judged by drawing a line so as to touch each of the present whorls across each side of the shell; the point at which they met was assessed as being approximately the original apex of the shell (Cox 1960). All specimens are deposited in the Australian Museum (AM), Sydney. All specimens were prepared using a diamond drill-bit attached via a flexible lead to a high-speed rotary motor. Shell measurements were made to the nearest 0.05 mm using dial calipers.

Systematics

Class GASTROPODA

Subclass ORTHOGASTROPODA

Superorder CAENOGASTROPODA

Order ARCHITAENIOGLOSSA

Superfamily AMPULLARIOIDEA

Family VIVIPARIDAE Gray, 1847

Diagnosis

Medium to large dextral, turbiniform shells, body whorl rounded, spire moderately high, pointed; aperture wide, round, parietal fold present or absent; operculum horny, subspiral (modified after Smith 1992).

Remarks

The above diagnosis follows Smith (1992), modified to accommodate the presence of a parietal fold in the new genus described below. Viviparid snails are, as their name suggests, viviparous (live bearing) and are found in both lotic and lentic systems throughout the world (Browne 1978). Within Australia the family is currently represented by the extant native genera *Notopala, Larina* and *Centropala* (Smith 1992). A species accidentally introduced from Asia, *Bellamya heudei guangdungensis* (Kobelt, 1906), recorded by Shea (1994) as established in New South Wales, is not considered part of the Australian fauna in this study. The Australian members of the family have undergone substantial revision over many years (Cotton 1935a, 1935b; Sheldon & Walker 1993; Stoddart 1982); the use of intraspecific shell variation and morphometric data by recent authors has resulted in a substantial reduction in the numbers of accepted species. Shell colouring and pattern and the form of the operculum, which are important characters in

determining generic placement in this family, are characters lost in most fossils.

The present specimens from Lightning Ridge are over 100 million years old (Albian [108–97.5 Ma]) and totally opalised. While sculpturing on some specimens has been preserved, colour bands and opercula have not; therefore, only structural shell characters could be used to assign them to taxa. Two major factors have been taken into account before deciding to place them in Viviparidae — the shell morphology, which fits within the currently accepted diagnosis of the family with only slight modification (the presence of the parietal fold in the two new species); and the freshwater depositional environment from which they originated. Whilst all the specimens can be accommodated within the family Viviparidae, those possessing a parietal fold cannot be assigned to any currently recognised genus and are considered to belong to a new genus which is described below. Direct comparisons between species, living or fossil, are few (Brown 1980); however, due to the lack of colour patterns and opercula as well as soft parts in these fossils, the only remaining methods are based on morphology. Therefore, we have applied parts of the morphometric data gathered by Sheldon and Walker (1993) to justify the placement of these specimens within Viviparidae, and in one case in the extant genus *Notopala,* and to offer a method of comparison between extant- and extinct species. None of the data comparisons are in any way intended to suggest relationships between members of either the *Notopala* sp. presented here or the new genus and any extant species.

Genus *Albianopalin* gen. nov.

Diagnosis

Shell dextral, thick, solid, globose to subglobose, ventricose, three–five whorls, subumbilicate; aperture subovate, large, approximately equal to height of spire; parietal fold present, simple. Operculum unknown.

Type species

Albianopalin benkeari sp. nov.

Etymology

From the combination of *Albian*, n. referring to age of the Lower Cretaceous opal-bearing deposits of the Griman Creek Formation, and *opalin*, Middle English, from *opalus*, Latin, alteration of Greek *opallios*, for 'opal'.

Remarks

While this new genus has similarities to *Notopala* (Cotton, 1935b), *Albianopalin* gen. nov. is easily separated from *Notopala* and all other genera within the family by the presence of a parietal fold in the basal lip, currently a feature unique to this genus within the family.

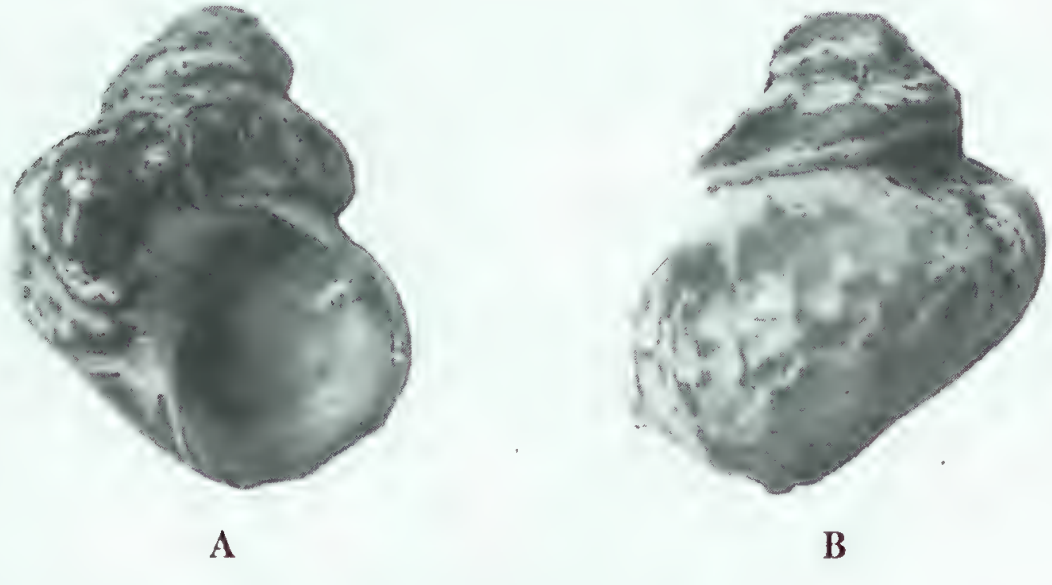

FIGURE 1. AMF122185 *Albanopalin benkeari* sp. nov. in **A**, apertural and **B**, dorsal views.

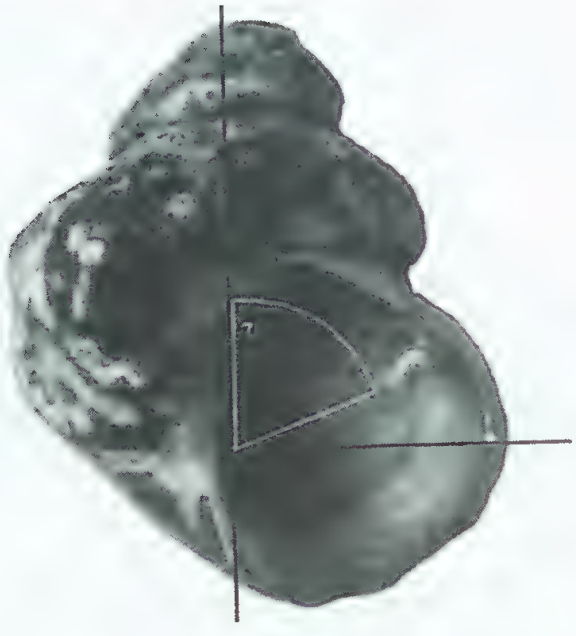

FIGURE 2. AMF122185 *Albanopalin benkeari* sp. nov. in apertural view showing angle of parietal fold.

Albianopalin benkeari sp. nov. (Figs 1, 2, Appendix)

Diagnosis

With the features of the genus; parietal fold simple, 70° from vertical axis.

Type specimen

Holotype: AMF122185 (Figs 1, 2, Appendix)

Locality and horizon

Lightning Ridge opal fields (precise site within the opal fields unknown), northern New South Wales, Surat Basin, Griman Creek Formation, middle–late Albian.

Description

Shell 17.7 mm high, 16.4 mm maximum diameter, dextral, turbiniform, subglobose. Teleconch with three complete whorls and broken parts, pointing to the possible presence of further whorls. Whorls impressed. Relatively evenly spaced spiral prosocyrt ornamentation present on many areas of teleconch. Aperture large (10.85 mm high), round; basal outer lip varicose with no evidence of eversion. A single, triangulated parietal fold (3.0 mm long, 1.0 mm wide, 2.0 mm deep) present on upper surface of basal lip, deepest side facing adaperturally (Fig. 2).

Etymology

Named for Ben Kear, for his assistance in this study.

Remarks

Holotype unique. The position of the parietal fold separates *A. benkeari* sp. nov. from the other new species described below. The holotype specimen is undistorted, but the spire is incomplete. Extrapolation from the spire angle indicates that there may have been at least four and as many as five complete whorls originally. Being opalised, the state of preservation of the holotype is very good, with much of its detailed surface ornamentation preserved.

Albianopalin lizsmithae sp. nov. (Figs 3, 4, Appendix)

Diagnosis

With the features of the genus; parietal fold simple, 112° from the vertical.

Type specimen

Holotype: AMF122186 (Figs 3, 4, Appendix)

Locality and horizon

Lightning Ridge opal fields (precise site within the opal fields unknown), northern New South Wales, Surat Basin, Griman Creek Formation, middle–late Albian.

Description

Shell, 15.1 mm high, 12.9 mm maximum diameter, dextral, turbiniform, subglobose. Teleconch with two complete whorls and broken parts, pointing to the possible presence of further whorls. Whorls impressed. This particular specimen has undergone some dorsoventral compression which has resulted in distortion, especially at base of final whorl. Aperture large (9.95 mm high), round; basal outer lip varicose with no evidence of eversion. A single, basal parietal fold (3.75 mm long, 2.3 mm wide, 2.2 mm deep) is present on surface of basal lip, deepest side facing adaperturally (Fig. 4). Spiral prosocyrt ornamentation present on parts of teleconch, especially proximal to aperture.

Etymology

We name this species for our colleague Elizabeth (Liz) Smith of the Australian Museum (AM), for her assistance in this study.

FIGURE 3. AMF122186 *Albanopalin lizsmithae* sp. nov. in **A**, apertural and **B**, dorsal views.

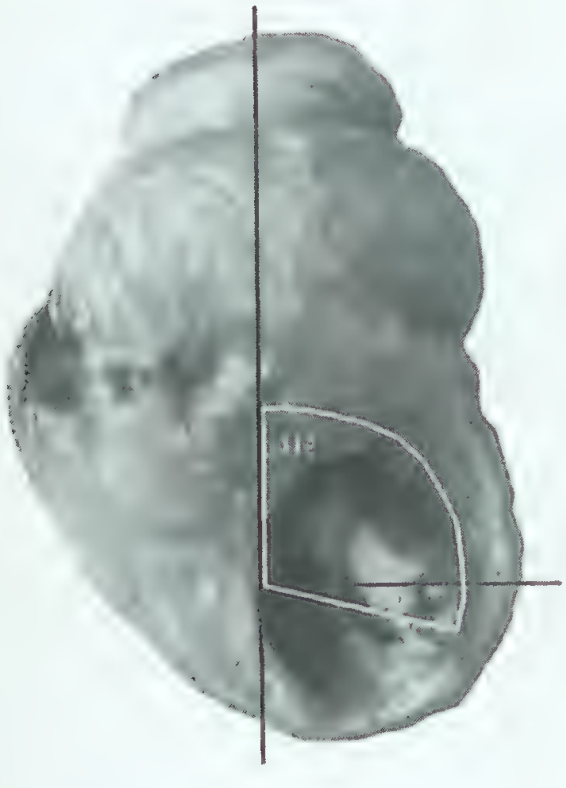

FIGURE 4. AMF122186 *Albanopalin lizsmithae* sp. nov. in apertural view showing angle of parietal fold.

Remarks

Holotype unique. The position of the parietal fold separates *A. lizsmithae* sp. nov. from *A. benkeari* sp. nov. as described above. The holotype has undergone moderate dorsoventral compression, resulting in the specimen appearing stretched. Like *A. benkeari* sp. nov., the spire is incomplete, and extrapolation from the spire angle indicates that there originally may have been at least four and as many as five complete whorls. Being opalised and having damage to parts of the surface of the teleconch, the state of preservation is good enough to preserve some of its detailed surface ornamentation.

Genus *Notopala* (Cotton, 1935b)

Type specimen

Type species: *Paludina hanleyi* (Frauenfeld, 1864) by original designation.

Diagnosis

Shell dextral, globose–conic, subumbilicate, five whorls, ventricose to angulate below the periphery; aperture subovate, large, about equal to height of spire; parietal fold absent; operculum corneous.

FIGURE 5. AMF13001 *Notopala* sp. in **A**, apertural and **B**, dorsal views.

Remarks

These specimens are extremely significant. Until their discovery, none of the currently living native Australian viviparid genera were known from deposits older than Plio-Pleistocene. This temporal range is now extended back to the Lower Cretaceous (middle–late Albian). It is also interesting to note that another living species, the lungfish *Neoceratodus forsteri,* has been recorded from the Griman Creek Formation of Lightning Ridge (Kemp & Molnar 1981).

Notopala sp. (Fig. 5, Appendix)

Referred material

AMF13001 (Fig. 5), AMF122166–AMF122184 (not figured herein).

Locality and horizon

Lightning Ridge opal fields (precise site within the opal fields unknown), northern New South Wales, Surat Basin, Griman Creek Formation, middle–late Albian.

Description

Shell dextral, turbiniform, subglobose. Teleconch with two to three complete impressed whorls; the incremental angle of the shell indicates that there were originally four or five whorls. Aperture large, round; basal outer lip varicose with no evidence of eversion.

Remarks

There is considerable variation in size, state of preservation, degree of corrosion and/or damage to the shells, opalisation, amount of matrix deposition on the shells, completeness of the aperture and presence/absence of ornamentation. We have not described these specimens as a new species at this stage. We feel that the exact taxonomic position of this material compared with other species in the genus requires further study. The preceding table (Table 1), diagram (Fig. 6, modified from Sheldon & Walker 1993) and graph (Fig. 7) show measurements of shell characters for each of the living Australian species of *Notopala*, and illustrate morphometric similarity of the specimens of *Albianopalin* nov. sp. as well as *Notopala* sp. described here to existing members of the genus. However, the specimens of *Notopala* sp. vary greatly in their physical condition, and it has not been possible to take the full range of measurements from each of the 20 specimens being studied. The reason for the inclusion of this data is not to demonstrate any relationship between extant species and the specimens from Lightning Ridge, but to show that the physical characteristics of the new material (*Albianopalin* sp. nov. and *Notopala* sp.) fit within the parameters for inclusion in the family Viviparidae.

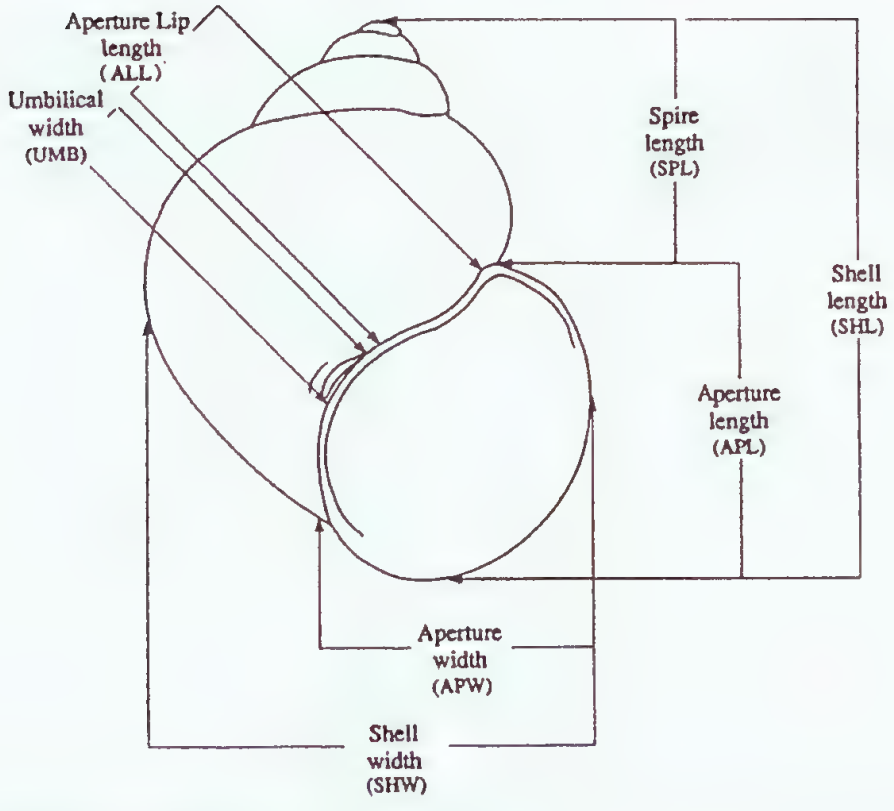

FIGURE 6. Diagram illustrating measurement parameters used in the morphometric analysis (modified from Sheldon & Walker 1993).

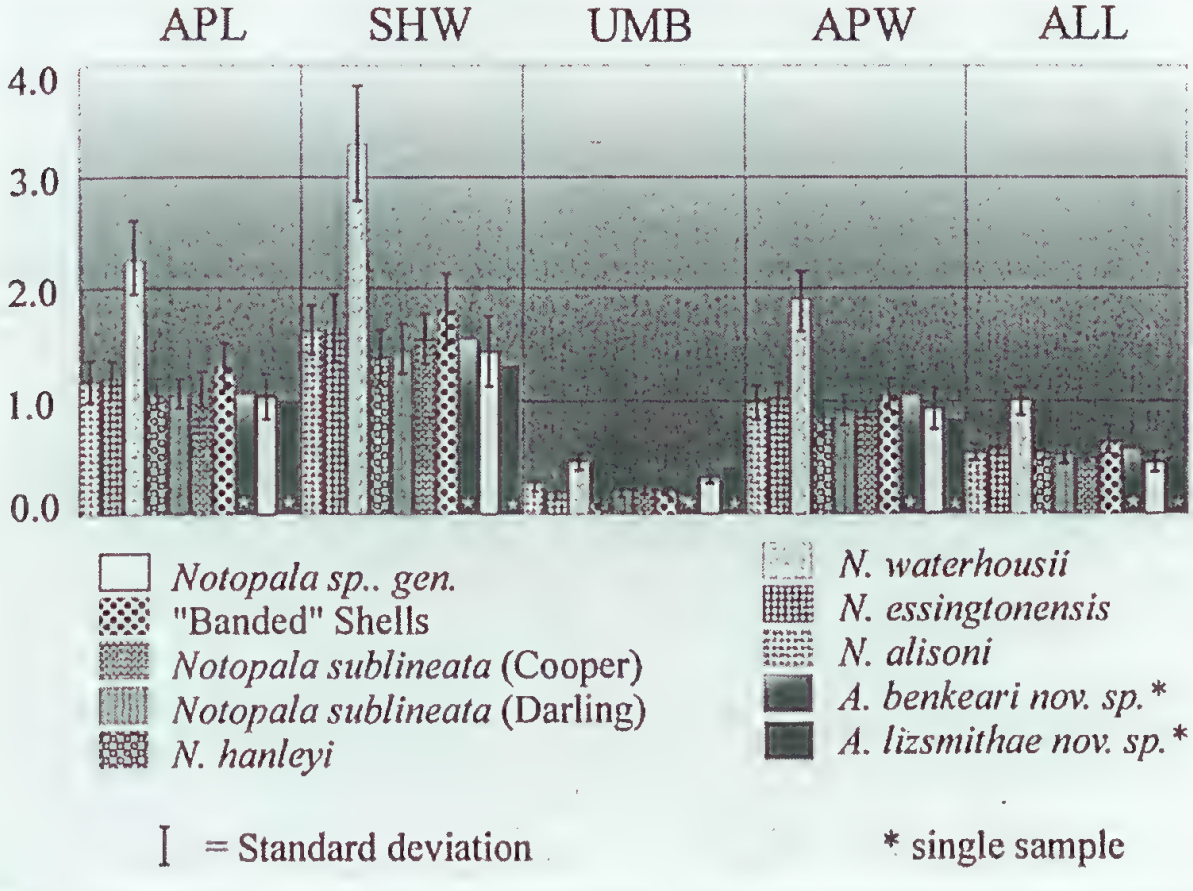

FIGURE 7. Histogram showing results of morphometric analysis. Taxa include living species of *Notopala* (modified from Sheldon & Walker 1993), *Notopala* sp. (AMF13001, AMF122185–122184), *Albianopalin benkeari* (AMF122185) and *A. lizsmithae* (AMF122186).

TABLE 1. Mean shell measurements (mm) for various living species of *Notopala* (*modified from Sheldon & Walker 1993) compared with those for *Notopala* sp. (AMF13001, AMF122185–122184), *Albianopalin benkeari* (AMF122185) and *A. lizsmithae* (AMF122186). Because not all specimens of *Notopala* sp. were complete, the number (n) of specimens used for each individual parameter is indicated separately. Standard deviation (SD) rows were not included for *A. benkeari* and *A. lizsmithae* as only a single specimen has currently been recovered for each of these taxa. Abbreviations: SHL, shell length; APL, apertural length; SHW, shell width; UMB, umbilical width; APW, aperture width; SPL, spire length; ALL, aperture lip length.

Species	Number		SHL	APL	SHW	UMB	APW	SPL	ALL
**N. alisoni*	20		21.59	11.91	16.3	02.59	09.77	14.78	05.35
(Brazier, 1979)		SD	*0.086*	*0.039*	*0.054*	*0.014*	*0.034*	*0.064*	*0.015*
**N. essingionensis*	20		21.70	12.00	16.58	1.96	10.10	14.47	6.11
(Frauenfeld, 1862)		SD	*0.082*	*0.038*	*0.067*	*0.016*	*0.038*	*0.067*	*0.025*
**N. waterhousii*	10		38.59	22.84	33.14	4.63	18.88	25.01	10.02
(Adams & Angus, 1864)		SD	*0.209*	*0.105*	*0.164*	*0.024*	*0.087*	*0.131*	*0.043*
**N. hanleyi*	42		16.67	10.50	13.83	1.29	8.52	11.00	5.57
(Frauenfeld, 1862)		SD	*0.520*	*0.026*	*0.036*	*0.00*	*0.025*	*0.037*	*0.013*
**N. sublineata*	28		18.32	10.84	14.53	2.05	9.21	12.04	5.24
(D) (Conrad 1850)		SD	*0.063*	*0.024*	*0.040*	*0.012*	*0.026*	*0.039*	*0.016*
**N. sublineata*	35		19.46	11.06	15.52	2.21	8.89	12.59	4.93
(C) (Conrad 1850)		SD	*0.058*	*0.027*	*0.039*	*0.010*	*0.018*	*0.040*	*0.009*
*'Banded' shells	15		22.15	13.18	18.10	2.06	10.69	14.6	6.42
		SD	*0.110*	*0.053*	*0.008*	*0.011*	*0.045*	*0.079*	*0.029*
Notopala sp.	20		–	10.35 (19)	14.43 (20)	3.24 (10)	9.20 (15)	–	4.71 (9)
		SD	–	*2.563*	*3.053*	*0.616*	*1.80*	–	*1.071*
A. benkeari	1		17.7	10.85	16.4	3.35	9.85	–	6.2
A. lizsmithae	1		15.1	9.95	12.9	3.4	8.15	–	4.4

Discussion

Albianopalin benkeari sp. nov., *A. lizsmithae* sp. nov. and *Notopala* sp. share the distinction of being the three oldest known definitively assigned members of the Viviparidae in Australia and thus serve to extend the range of the family in this region back to at least the uppermost Early Cretaceous. Since the family is confidently known from the Jurassic to Recent in Europe, Viviparidae therefore appears to be an ancient pre-Jurassic group of probable Pangean origin. By the Cretaceous, the family had diversified within the Gondwanan region into a range of endemic genera and species.

While there are numerous Cretaceous records of freshwater bivalves from Australia (Dettman et al 1992; Hocknull 1997; Jell & Duncan 1986; Ludbrook 1985; McMichael 1957), there are very few for non-marine gastropods from the same period. The reasons for this apparent absence are unknown, but could be related to preservational biases (with shells rapidly breaking up or dissolving after death). Another possibly reason could be a lack of gastropod species due to poor tolerance of the strongly seasonal near-freezing climatic conditions which characterised many Australian high latitude depositional environments during the Early Cretaceous.

The implications of this study, combined with subsequent investigations, could eventually demonstrate a Gondwanan and possibly Australian radiation for many of the species living around the globe today.

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APPENDIX

Measurements (mm) of all Lightning Ridge gastropod specimens used in this study (AMF13001, AMF122166–AMF122186). Abbreviations: SHL, shell length; APL, apertural length; SHW, shell width; UMB, umbilical width; APW, aperture width; SPL, spire length; ALL, aperture lip length. Spire length measurements are omitted owing to incomplete apices in all specimens sampled.

Specimen	SHL	APL	SHW	UMB	APW	ALL
1. AMF122185 (type *A. benkeari*)	17.70	10.85	16.40	3.35	9.85	6.20
2. AMF122186 (type *A. lizsmithae*)	15.10	9.95	12.90	3.40	8.15	4.40
3. AMF13001 (*Notopala* sp.)	19.25	12.00	17.30	3.75	11.10	5.02
4. AMF122166	17.65	11.05	14.50	–	8.55	–
5. AMF122167	14.37	8.75	12.75	8.50	–	–
6. AMF122168	11.60	–	11.85	2.30	7.80	3.35
7. AMF122169	15.62	8.80	12.45	3.00	–	5.00
8. AMF122170	12.60	8.80	11.65	3.00	7.65	4.35
9. AMF122171	19.00	13.25	19.90	–	12.20	–
10. AMF122172	20.42	12.10	17.20	4.20	–	6.00
11. AMF122173	18.00	11.05	16.20	3.90	9.80	–
12. AMF122174	17.92	11.20	15.55	–	11.15	–
13. AMF122175	19.82	12.63	17.85	3.35	–	–
14. AMF122176	19.35	11.10	16.75	–	10.50	–
15. AMF122177	19.57	12.65	17.50	–	11.70	–
16. AMF122178	18.55	10.05	15.15	–	–	–
17. AMF122179	17.95	11.30	15.20	3.80	9.60	4.80
18. AMF122180	10.22	6.50	9.00	–	–	6.00
19. AMF122181	6.92	7.20	9.40	2.60	6.15	3.60
20. AMF122182	9.32	6.50	8.75	2.35	5.60	3.15
21. AMF122183	17.80	11.70	16.00	–	9.80	–
22. AMF122184	–	16.10	10.10	13.40	–	8.30

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ORNAMENTAL DIAMOND PATTERNS IN ABORIGINAL BARK PAINTINGS FROM N.E. ARNHEM LAND, AUSTRALIA

EMIL MAKOVICKY

MAKOVICKY, E. 2003. Ornamental diamond patterns in Aboriginal bark paintings from N.E. Arnhem Land, Australia. *Records of the South Australian Museum* **36**(1): 1–20.

This paper is a symmetrological study of the geometric art of Aboriginal bark paintings from northeastern Arnhem Land, Australia. Ornamental diamond patterns in these paintings display complex symmetries and the current study tests the feasibility of a symmetrological approach to the description of these patterns and to the definition of the artistic canons of different clans of the Yirritja moiety. This first attempt furnishes all the necessary methods and definitions for detailed follow-up studies of the subject.

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Introduction

The bark paintings of Arnhem Land are perhaps the finest creations of contemporary Aboriginal art. Their technical excellence is combined with considerable stylistic variation across the region from east to west. In western Arnhem Land the background to the figures tends to remain free of infilling while the figurative representations are infilled; the opposite is practised in northeastern Arnhem Land. Infilling is not practised elsewhere in Australia (Morphy 1981: 56).

In general, bark paintings and other works of art are representations of the ancestral past (Dreamtime) when the world creators transformed the earth through their actions, creating the entire landscape as it is known to the Aborigines today — landforms, skies, flora, fauna, geography and social structures. The Ancestral Beings entrusted distinct areas of northeastern Arnhem Land to different clans for perpetuity (Morphy 1981: 59). The paintings are in many cases believed to be inherited from Ancestral Beings and they relate to them and the stories about their deeds on a number of levels with progressively deeper meaning.

Via connections between particular Ancestral Beings and distinct clans/moieties, a system of ownership or distribution of rights in paintings developed. In northeastern Arnhem Land these rights are exercised by patrilineal clans or their sections. A person also has some rights in the paintings of his mother's clan. Control over paintings and propagation of knowledge about them belongs to the senior male members of the clan; learning the interpretation of designs is a part of male initiation (Morphy 1981: 57).

Aboriginal artists employ four colours — red, white, black and yellow — combining ochres, manganese oxides, charcoal, kaolin and other white materials with, originally, plant juice fixative. A sheet of bark is flattened with the help of fire and its surface smoothened. The surface priming is done by means of red, rarely black or yellow, ochre colour. Selected areas of the sketched design are infilled with cross-hatching. According to Caruana (1994: 26), cross-hatched clan designs are called *dhulang* in northeastern Arnhem Land. At first, the ground is covered with parallel white lines. A second set of lines is painted across it in white, red, yellow or black; sometimes also in an alternating colour sequence. Flat colouring is used as well; dotted patterns are infrequent.

The cross-hatching in two or more colours adds a radiating shimmer to the Aboriginal bark paintings (Morphy 1992); this brilliance technique is shared with the paintings of very few other cultures. The difference between the cross-hatched, shimmering areas and the flat-coloured patches is the fundamental means of artistic expression in the patterns treated in this study.

According to Morphy (1981: 64), the main components of northeastern Arnhem Land paintings are the ground colour, a border, dividing lines (compartments) and the figurative and geometric representations. The figures form a narrative scene that is often understandable

only to the initiated men and has different depths of meaning. The geometric elements are not iconic and an element can have a host of meanings depending on the context; its decoding requires prior instruction. The geometric patterns are owned by distinct clans; their similarities and differences reflect those between these social groups. The style of northeastern Arnhem Land is a product of combining two different (ie figurative and geometric) systems of representation (meaning) in one painting. Geometric elements are especially important for paintings created in closed context with a restricted, initiated audience.

There are two principal categories of geometric patterns in the bark paintings from northeastern Arnhem Land: two-coloured or multicoloured stripe patterns and similarly coloured diamond patterns; they rarely combine in striped diamonds.

The diamond patterns (owned by the clans of the Yirritja moiety) are the object of the present study. The richness and unparalleled sophistication of their colouring schemes appears worthy of a symmetrological/crystallographic study from at least two points of view. On the basis of our observations, we believe that the colouring is yet another, large-scale device to enhance the brilliance (the shimmering effect) of Yirritja bark paintings, and this unique artistic device deserves a more detailed description. On the other hand, this colouring might indicate the kinship between different clans and moieties. Thus far, only the overall pattern shapes have been invoked in the latter context (Morphy 1981: 62).

The studied material is primarily based on photographs collected by Prof. Howard Morphy prior to 1980 and unselfishly made available for the current project. This choice enabled the author to concentrate upon an older period of Aboriginal bark painting, preceding its present market context. It has been supplemented by observations made in the collections of the University of Western Australia and several thematic exhibitions as well as by published photographic material.

The author is aware of the limited size of the sample of material studied. However, the present paper is an exploratory analysis of the problem: its primary purpose is to investigate the feasibility of a symmetrological approach to the complex colouring schemes rather than producing definitive answers on their applicability to the kinship and inheritance problems.

Selected Examples

Figure 12, painted by a member of the Dhalwangu clan in 1975, contains two black-coloured long-necked tortoises in a 2-fold rotation arrangement on the back of a yellow tortoise; the high symmetry of the yellow tortoise body is broken only by its long neck. Water courses appear indicated by a cross-hatched striped pattern and tracks from tortoise feet. All are two-coloured on white background. Additional interpretations can be found in Morphy (1979: 309).

Four quadrants of the painting contain a diamond pattern outlined in yellow ochre and white frames and occasionally degenerated into a zig-zag. Investigating the periodicity of this pattern, we observe that the diamonds at the corners of a rectangular mesh are flat-coloured whereas the central diamond is cross-hatched. The flat-coloured diamonds are alternatively coloured red and black. The cross-hatched pattern is three-coloured, repeating the sequence white–red–white–black– (repeat). The resulting repetition period is a 4-fold of the basic one, a double of the flat-coloured sequence. The black–red alternation, occasionally also the red–yellow alternation on white background, dominates the painting.

The painting by a member of the Madarrpa clan (1975) in Figure 13 is compartmentalised perpendicular to its length into alternating striped, fish-populated 'water' portions and diamond-covered portions without iconic element. A broad-bodied crocodile occupies the entire long axis of the painting with enough space to depict its scales as a diamond pattern.

The black–red alternation dominates the painting. With one possible exception of one-coloured flat-coloured diamonds, the red–black exchange takes place perpendicular to the picture length. All cross-hatched patterns — those present as stripes or those included in the diamond fields — have a white–red–white–black– (repeat) colouring periodicity, parallel to the previous colour change. Diamond fields have non-diamond 'tails', giving the painting a forward thrust.

The two paintings by the Gumatj clan (1975) in Figures 14 and 15 offer multiple complications of the diamond scheme. Fig. 14 depicts a story of birds tracking along the picture and a goanna. The animals track across red and black striped fields on white cross-hatched background. Fields of diamonds occur in all four quarters, alone or as integral parts of a presumed landscape through which the birds track. The flat-coloured designs are either one-coloured (red) or, in the majority of

cases, show a red and black sequence. The cross-hatched patterns are either yellow–black sequences parallel to the previous ones or three-colour sequences with periodicity faults.

Figure 15 consists of a kangaroo attacked by a crocodile and, presumably, a large ray-fish, and presents an array of diamond colouring schemes. The attack itself takes place in a river, cross-hatched red and black on white background. The flat-coloured diamonds are mostly two-coloured, red–black, red–ochre yellow, rarely only red. The arrays of cross-hatched patterns are more complicated: chessboard ochre and black or two-coloured black and yellow rows separated by white rows. The latter case again has two variations, according to a parallel or a chessboard scheme for the components of the coloured rows.

The Gumatj painting in Figure 1, produced in 1959–60, has one system of diamonds, changing to zig-zagging paths, all flat-ochre coloured.

FIGURE 1. Bark painting by a member of the Gumatj clan (1959–60). Courtesy of H. Morphy.

Cross-hatched red and black striped areas with white background surround the black and ochre figures with spear throwers, separated from two black trees by a narrow river. The cross-hatched diamonds are one-coloured in the majority of fields (finely ochre and red ruled). In the uppermost main field, a unique sequence of colour–colour–white repeats; in the central lower panel three-coloured cross-hatched diamonds are present, coloured either parallel or antiparallel to each other.

The painting in Figure 2 (Gumatj clan 1975) recounts the story of a freshwater crocodile and fish in a red and white striped river. Three transversal compartments contain six diamond fields with rich ornamentation. All flat-coloured diamonds are one-coloured, red with expressive white frames. The cross-hatched diamond subset oscillates, by way of errors in repetition, between the three-coloured sequences black–red–white–black–red–white– (repeat) and black–red–white–red–black–white–black– (repeat), respectively;

FIGURE 2. Bark painting by a member of the Gumatj clan (1975). Courtesy of H. Morphy.

both of these are present as a sufficiently long pure sequence. A fragment of the sequence red–black–red–black– (repeat) and that of white–red–white–black– (repeat) (as well as pure cross-hatched white on the crocodile's back) have been employed as well. The former long colour sequences and the 'one-coloured' river stripes produce a colour impression very distinct from the previous examples.

These examples show a need for systematisation of coloured diamond patterns from northeastern Arnhem Land if further study is to be undertaken. The science of symmetry offers the most efficient means for such systematisation.

Fundamental Language of Symmetry

The Aboriginal diamond patterns are by their nature two-dimensional periodic patterns. In such patterns a single motif (eg an individual lozenge) or motifs repeat infinitely. All repetitions of a given motif are related to each other by one or several exactly defined ways, called operations of symmetry. All symmetry equivalent motifs have the same shape and size and the same surroundings from the point of view of symmetry and geometry. The symmetry-equivalent motifs can be related to each other by translation (pure displacement without a change in orientation), reflection (on a reflection axis in the plane of the pattern or on the reflection (= mirror) plane *m* perpendicular to the plane of the pattern, depending on the nomenclature used by the particular author; see Fig. 3e) or rotation (by an angle of n/360° around an n-fold rotation axis perpendicular to the plane of the pattern; the permitted values of n are 2, 3, 4 and 6; see Fig. 3a). A combination of reflection with translation (by half of the full repetition period of the periodic pattern) gives glide-reflection planes (axes) *g* (Fig. 3f).

From the infinite number of translation vectors between the periodically displaced copies of the same motif that can be found in a two-dimensionally periodic pattern, we usually select the two shortest ones. For the symmetries observed in the present work, these comprise an angle of 90° or quite a general obtuse angle and they are not equal in length and kind (eg Figs 3c,d; 4a; 5a,d). The two vectors define a parallelogram, by the translation (displacement) of

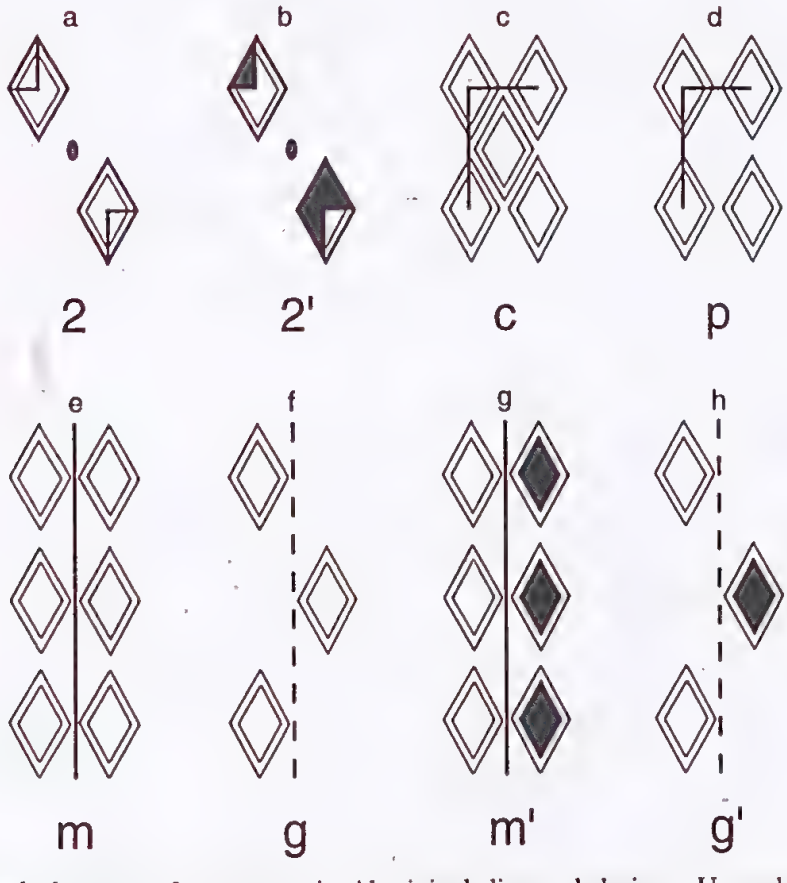

FIGURE 3. Fundamental elements of symmetry in Aboriginal diamond designs. Unmarked symbols (eg *m*) are colour-preserving elements whereas the primed symbols (eg *m'*) are elements of dichroic symmetry; *p* and *c* — primitive and centred unit mesh with the *a* (vertical) and *b* (horizontal) axes indicated; 2 — twofold axis; *m* — mirror plane; *g* — glide reflection plane.

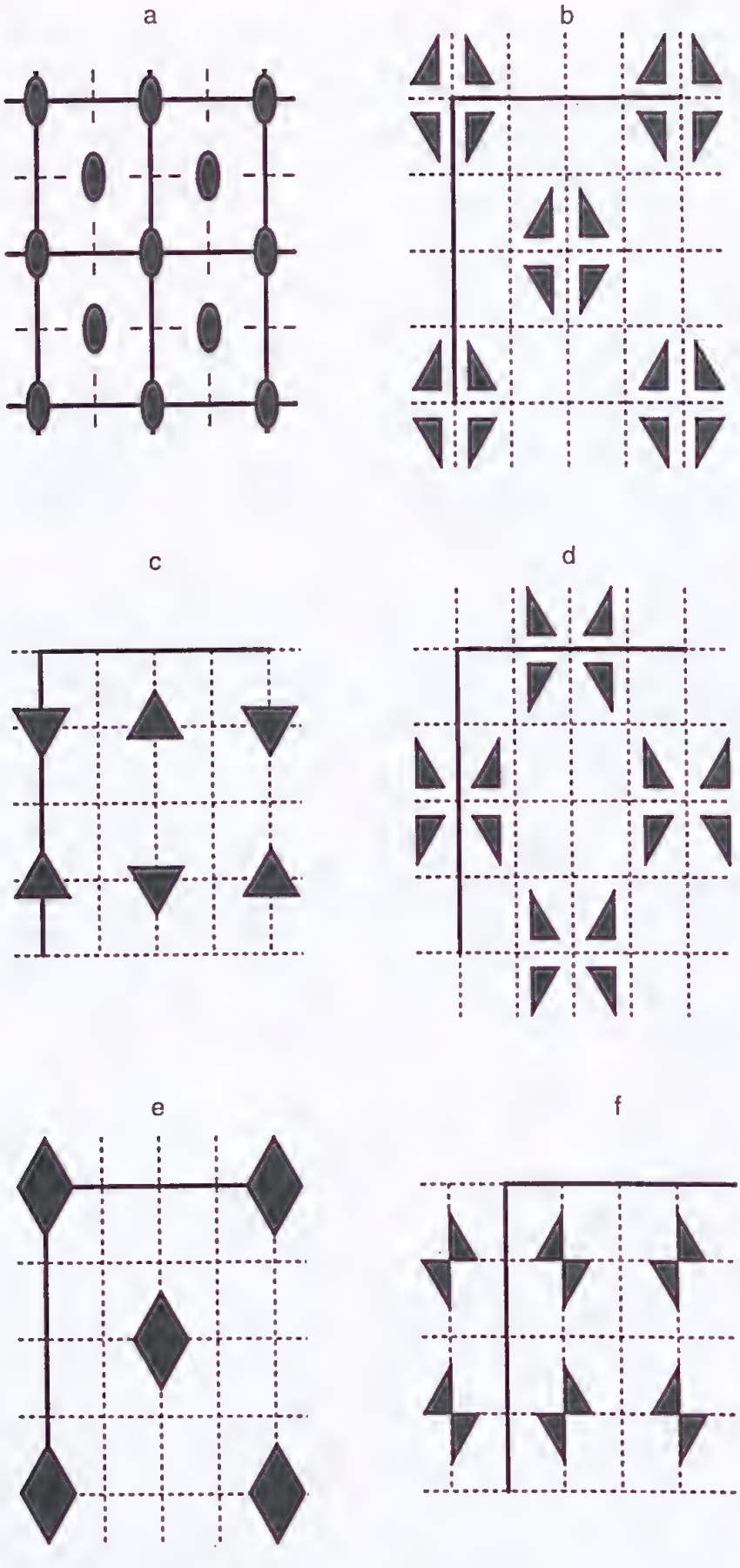

FIGURE 4. Plane group *cmm*. **a**, reflection planes, glide-reflection planes and 2-fold axes in one unit mesh. In **b** to **f**, unit mesh axes (full lines) and position of symmetry planes (stippled) are indicated: **b** and **d** show an asymmetric motif in a general position and **c**, **e** and **f** show motifs in special positions (**c**, motif on reflection planes, **e**, motif on *2mm* intersections, and **f**, motif on 2-fold axes; all motifs with appropriate own symmetry).

which the entire pattern can be reconstructed. This parallelogram is called a unit mesh (unit cell). The unit mesh is primitive when the translation-equivalent copies of the motif are only in its corners (Fig. 3d), or centred when an additional copy lies in its centre (Fig. 3c).

Only five basic shapes of unit mesh exist in planar patterns. All the patterns with a given type of unit mesh belong to the same system. These systems are as follows (a and b are the selected vectors, γ is their angle):

i) Oblique ($a \neq b$, $\gamma \neq 90°$); symmetry represents pure translations or translations and 2-fold axes

ii) Rectangular ($a \neq b$, $\gamma = 90°$, Figs 3d, 5e, 6a); symmetry elements present: reflection planes and glide-reflection planes that can be combined with each other and with 2-fold axes

iii) Diamond (rhombic, centred rectangular) system which can either be described by a diamond-shaped mesh ($a = b$, $120° \neq \gamma \neq 90°$) or by a rectangular mesh with an additional translation-equivalent point in its centre, a so-called centred mesh ($a \neq b$, $\gamma = 90°$, Figs 3c, 4a); relevant symmetry represents a combination of reflection and glide-reflection planes with or without 2-fold axes

iv) Square ($a = b$, $\gamma = 90°$); 4-fold axes combined with 2-fold axes with or without reflection and glide-reflection planes

v) Hexagonal (equilateral triangular) ($a = b$, $\gamma = 120°$); 3-fold axes with or without reflection and glide-reflection planes, or 6-, 3- and 2-fold axes with or without these planes of symmetry.

The second and third systems are most relevant for the present study; less frequent is the first one. For our diamond patterns, the γ angle of the oblique unit mesh is determined by the position and shape of the diamonds; if symmetry is ignored, metrically they are still rectangular. The hexagonal and square systems, so relevant for Islamic patterns (Abas & Salman 1995: 138; Makovicky & Makovicky 1977), are absent in Aboriginal art.

The operations of symmetry in the plane form unique combinations, the so-called plane (or two-dimensional) symmetry groups. Within these unique combinations of symmetry operations, any operation can be replaced by a combination of two or more other symmetry operations present in the given symmetry group. When two or more symmetry operations are combined, the result does not depend on the sequence of operations chosen. Finally, any operation in the group has its inverse — a combination of a symmetry operation and its inverse results in a transformed motif which is identical to the original. Only 17 distinct plane groups of symmetry can be found in all two-dimensional patterns, from which four have been encountered in the present study. From the above listing of two-dimensional systems, the presence of certain rotation axes and, for some cases, the presence/absence of reflection planes in a plane group determines the geometry of unit mesh and the system to which the plane group belongs.

Books on symmetry written by mathematicians often start with abstract mathematical groups, then proceed to derive the two-dimensional groups of symmetry and do not always get down to the problems of their practical application. An exception is the book by Abas & Salman (1995), in which a profusion of examples with basic symmetrological information attached are given. A non-mathematical approach to plane groups is taken by Washburn & Crowe (1998: 58) in a book intended to teach anthropologists 'the symmetries of culture'.

Crystallographers are perhaps the most frequent practical users of symmetry groups. The approaches and notions used in the present paper come partly from this experience. The chapters on symmetry in crystallographic textbooks range from highly mathematical (but always practical) to almost purely geometric; the reader can find an understandable/complete approach to plane groups in Klein (2002).

The crystallographic notation of plane groups used here consists of 4-place symbols. The first letter p or c denotes primitive or centred mesh, respectively (Figs 3c,d); the integer 'n' denotes the highest order of rotation (2-fold rotation for the present cases); the next letter denotes a mirror plane m or a glide-reflection plane g perpendicular to the a axis (which points downwards in each figure); and the following letter indicates such planes perpendicular to the b axis (which points to the right) (Figs 4, 5, 6).

Thus, for example, *cmm* denotes a centred mesh with mirror planes perpendicular to the mesh axes a and b; *p*2 denotes a primitive mesh with a 2-fold rotation axis; and *pgg* denotes a primitive mesh with glide reflections perpendicular to axes a and b (see Fig. 5).

The trivial factors (the directions to which no perpendicular symmetry planes exist) are omitted in the abbreviated symbols commonly used. They would have been denoted by '1' on the relevant

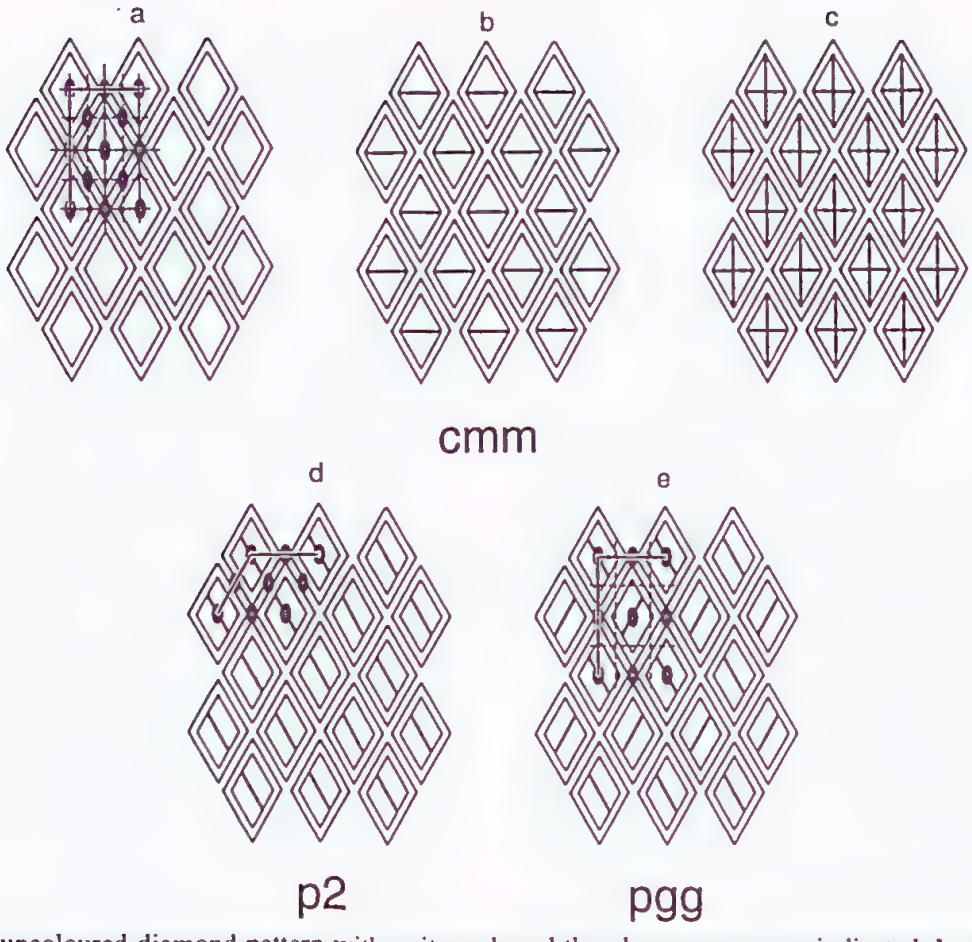

FIGURE 5. **a**, uncoloured diamond pattern with unit mesh and the plane group *cmm* indicated. **b** and **c**, pattern of halved and quartered diamonds, respectively (**a** and **b** contain special positions, **c** general positions). **d** and **e**, uncoloured diamond patterns with oblique partitioning: **d**, plane group *p*2, **e**, plane group *pgg*. In this and the following figures, the *a* axis of the mesh points downwards, the *b* axis to the right.

position of a full symbol. Other rules of notation are valid for the square and hexagonal systems, with 4-, 3- and 6-fold axes, which were not encountered in this study.

Application of plane groups of symmetry does not require their (re)derivation, but depends critically on their correct interpretation. In this connection, division of elements of the motif into those placed in general positions (not situated on any element of symmetry) and in special positions (situated on an element of symmetry or in an intersection of several elements of symmetry) is of the most fundamental importance although it is rarely mentioned outside the field of crystallography. An element (ie motif) in the special position ought to have symmetry at least equal to the symmetry elements on which it is positioned. If its symmetry is lower, it reduces the overall symmetry of the pattern; if it is higher, it may result in stacking errors in the design. An element in general position is asymmetric by virtue of its position. If it has any other symmetry, it again can lead to errors in pattern periodicity. As an example, the elements of, and the general and special positions in, the plane group *cmm* are illustrated in Figure 4. This group has a centred unit mesh and two sets of mirror planes, respectively perpendicular to the *a* and *b* axes. As can be seen in Fig. 4, these 'principal symmetry elements', which form part of the plane group symbol, are interleaved by glide-reflection planes. Two-fold axes occur on intersections of all symmetry planes of the same kind.

If the patterns encountered in the present study are studied on the uncoloured level (as field-and-line patterns) they are reduced to the patterns shown schematically in Figure 5. In the fundamental type, Fig. 5a, the framed diamonds can occasionally become squares or be partitioned into halves (Fig. 5b), but nearly all Aboriginal artists use the simple diamond grids from Fig. 5a.

In this pattern, each diamond is in a special position of the plane group *cmm*, on the intersection of two mirror planes and a 2-fold axis. Its shape (own symmetry) corresponds to this site symmetry (Fig. 5a). When the diamond is

symmetrically divided into two halves (Fig. 5b), each of these is still in (another) special position, straddling a mirror plane. When it is divided into four quarters (Fig. 5c), these are in general positions and, as a consequence, each of them is asymmetric.

If two opposite edges of a diamond element have been accentuated by a colour stripe (as done by the Aboriginal artists in some instances), its symmetry is reduced to 2-fold rotational only and the mirror planes are lost. The two simplest arrangements yield symmetry groups *p*2 and *pgg* (Fig. 5d,e, in which the edge stripes were enlarged to fill the entire halves of the diamond field).

We shall see that in the process of colouring, the Aboriginal artists often made consecutive rows of diamonds non-equivalent and effectively separated them from each other by giving them different colour sequences, symmetries and periodicities. Each subset of this kind has symmetry *pmm* before colouring is applied (Fig. 6a). If two opposite edges of each diamond are accentuated, subsets with symmetries *cmm*, *pgm* (both with a larger unit mesh) and *p*2 (Fig. 6b) result.

A simple extension of groups of symmetry can be achieved when a change of colour of the element (ie diamond) acted upon is assigned to each step of a particular operation of symmetry. A change of colour from 'white' to 'black' (and back in the next step) can be assigned to translations, centration, or 2-, 4- or 6-fold rotation, as well as to the reflection and glide-reflection planes. Such operations are called operations of antisymmetry and the symmetry groups are called dichroic or black-and-white, or groups of antisymmetry. In the case of two-dimensional

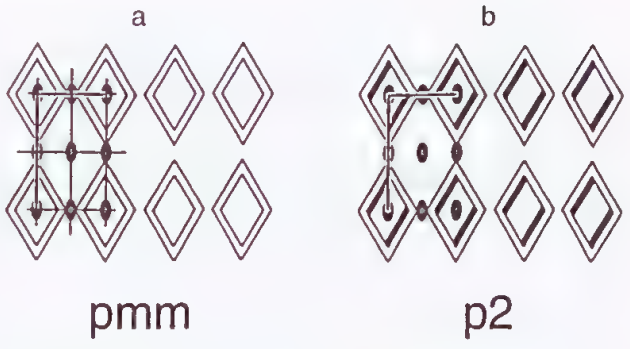

FIGURE 6. Two examples on an uncoloured diamond subset: **a**, plane group *pmm*, **b**, plane group *p*2.

periodic patterns in plane, 46 plane groups can be discerned when the above 17 uncoloured plane groups are not counted. In the symbols the colour-changing symmetry operators are primed, the colour-unchanging ones are left unprimed (Figs 3b,g,h).

The above discussed diamond patterns with symmetries *cmm*, *pmm*, *pgg*, *pgm* and *p*2 can yield a number of dichroic patterns. Examples are given in Figs 7–9. Several of them will be discussed in detail here.

Figures 1, 2 and 12–15 show dichroic patterns in which the diamonds at the vertices of the unit mesh are coloured in one way (flat colour) whereas those in its centre are coloured in a different way (cross-hatched). If these two styles of colouring are interpreted as black and white, respectively, this general colour scheme is identical with that in Fig. 7b. Using the *cmm* pattern in Figs 4a and 5a as reference, we can see that the following symmetry operations became colour-changing operations: the translation from the origin to the centre of the unit mesh, the glide-reflection planes and one half of 2-fold rotation axes (ie those along the lozenge edges). On the

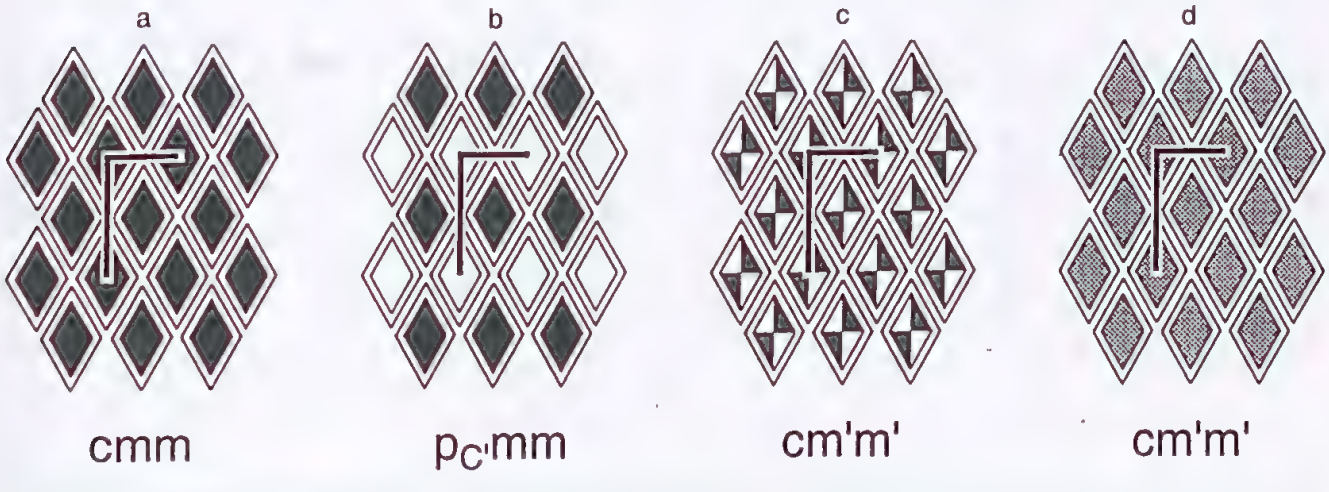

FIGURE 7. Dichroic plane groups for selected diamond patterns: **a**, the basic one-coloured pattern, **b**, $p_c mm2$ with special positions, **c**, *cm'm'* with general positions, **d**, ditto with a special position only.

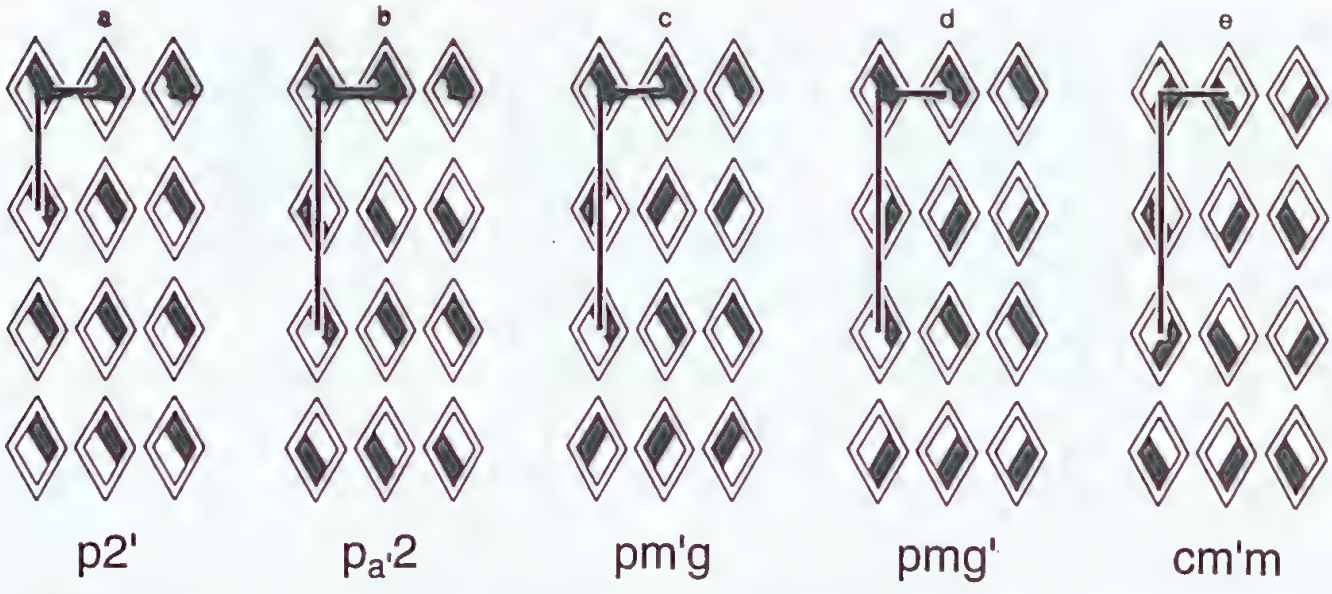

FIGURE 8. Dichroic colouring of a *p*2 diamond pattern: **a**, dichroic plane group *p*2', **b**, p_a2, of the *pmg* pattern: **c**, *pm'g*, **d**, *pmg'*; and of the *cmm* pattern: **e**, *cm'm*.

other hand, the 'principal symmetry elements' which enter the group symbol, ie the two systems of reflection planes, the other half of rotation axes and the translations along the unit-mesh edges, remain colour-preserving. Thus, this dichroic group can be described by the symbol $p_{C'}mm2$, where *C'* denotes the colour-changing operation of mesh centration.

On the other side of the spectrum is a *cm'm'* pattern (Fig. 7c), in which both systems of mirror planes and the associated glide-reflection planes change colour on reflection, whereas the centration vector and all 2-fold rotation axes (cf Fig. 5c) preserve the colour of elements they act upon. Pattern in Fig. 7c shows general positions for this group; that is, each lozenge is cut up into four parts which do not lie on any symmetry elements and could even be moved apart as in Fig. 4d of the uncoloured parent group. The colour of special positions, on *m'* planes or on *2m'm'* intersections, can be obtained by lumping the appropriate two or four quarters together and averaging their colour. They will be grey, with both black and white components present at the same time, and therefore will remain unchanged even if subjected to colour-changing operations of symmetry (Fig. 7d).

As a final example, the two simplest dichroic colourings of the *p*2 pattern shown in Figs 5e and 6b result in the patterns in Fig. 8a,b. In the first

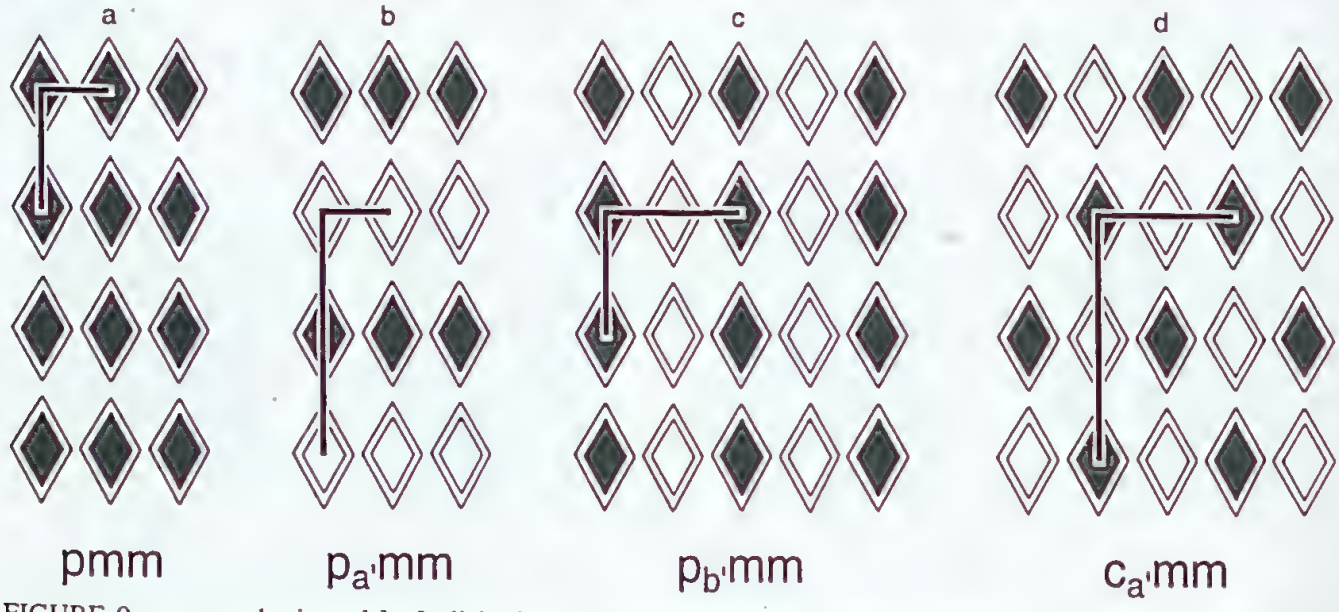

FIGURE 9. **a**, monochroic and **b–d**, dichroic, colouring of the *pmm* diamond subset; **b**, p_amm, **c**, p_bmm and **d**, c_amm.

case all 2-fold axes become colour-changing, resulting in symmetry $p2'$, whereas in the second case only half of their set will represent colour-changing operators. The latter case can be conveniently described as a doubling of one of the unit-mesh edges by a colour-changing translation, in this case as $p_a.2$. The cases based on the plane groups *pmg* and *cmm* give a broader spectrum of dichroic colouring (Fig. 8c–e).

A rectangular *pmm* example in Fig. 9a that can be coloured by a two-coloured translation *b'* or *a'* as $p_a.mm$ or $p_b.mm$ (Fig. 9b,c) leads towards a generalisation of this process for more than two colours, and to the simplest type of coloured groups of symmetry in which colours of all (or selected) elements of a pattern change periodically along one translation direction. Along this colour-modulation direction the fundamental translation of the pattern will change to its n-tuple for the sequence of n colours involved.

Thus, trichroic modulation of the *pmm* pattern of diamonds will result in a trichroic plane symmetry group with a tripled *b*-translation (Fig. 10). If we study the chromaticity (colour action) of mirror planes perpendicular to the colour-modulated *b* direction as well as that of 2-fold axes, we find that it is only partial for this case. These symmetry elements alternate only two colours, leaving the third one unchanged. The resulting plane group symbol is correspondingly complicated, $p_b^{(3)}mm^{(2,1)}2^{(2,1)}$. Superscripts in round brackets indicate the number of permutated colours and, following the comma, the number of unchanged colours. When ignoring the symmetry of the underlying pattern, this plane group can be simplified to $p_b^{(3)}m1$; in this case the colour scheme employed is presented as simple vertical

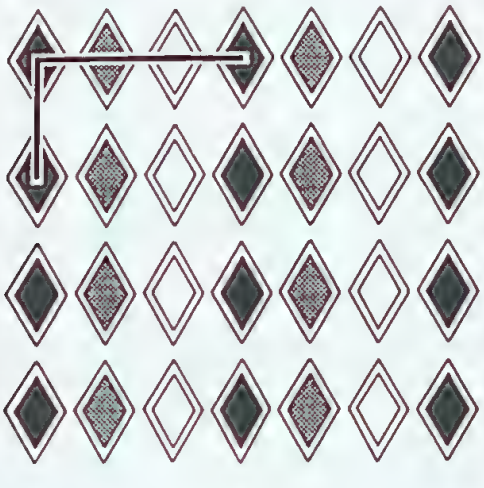

FIGURE 10. Trichroic modulation of the *pmm* diamond subset; trichroic plane group $p_b^{(3)}mm^{(2,1)}2^{(2,1)}$.

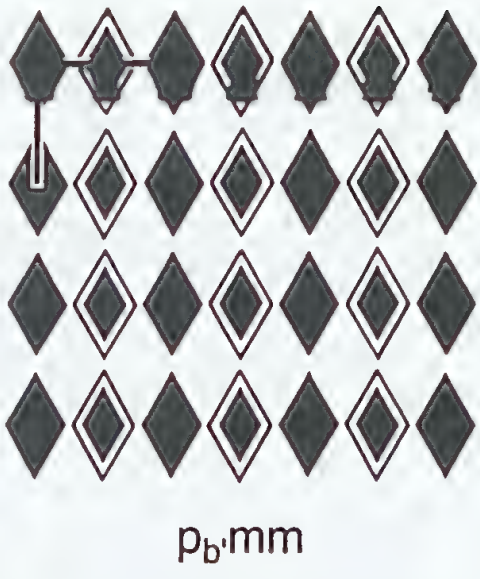

FIGURE 11. Diamond pattern from a crocodile's back. Gumatj bark painting. Colouring of diamonds is interpreted by a dichroic plane group.

colour stripes overlying the correspondingly coloured diamonds. Extension of the dichroic $c_a.mm$ principle in Fig. 9d to more colours is much more complicated; it can be seen, for example, on the cross-hatched diamonds of the drawing in Fig. 17f.

Classification of Observed Diamond Patterns

The observed diamond patterns can be classified according to the following properties of the colouring schemes employed by Aboriginal artists:

i) maximally two colours, black and red are used for flat-coloured diamonds, plain white being consistently avoided; the flat-coloured diamonds are either all of one colour or they are simply two-colour modulated

ii) one to three colours have been used for the cross-hatched diamonds — either the vector of the colour-modulation wave is parallel to the *b* axis, or the wave is diagonal to the two axes of the pattern; in rare cases, the colour modulation vector is parallel to the *a* axis.

The resulting classification is given in Table 1.

The Observed Symmetry Groups

As remarked earlier, the entire body of coloured diamond patterns suggests that, on the whole, the flat-coloured and the cross-hatched subsets are treated independently from each other. Their

TABLE 1. Colouring schemes observed for the two component subsets in the Aboriginal diamond patterns.

Colour type	Polychroism* (colour index)	Mesh size* & type	Wave-vector of colour modulation and coloured plane group	Expansion by intervening neutrally coloured stripes of diamonds parallel to *a*
Flat-coloured	1	*a* x *b* *p*	wave-vector undefined *pmm*	–
Flat-coloured	2	*a* x 2*b* *p*	*b* $p_b mm$	
Flat-coloured	3	*a* x 3*b* *p*	*b* $p_b^{(3)}mm^{(2,1)}2^{(2,1)}$	
Cross-hatched	1	*a* x *b* *p*	wave-vector undefined *pmm*	–
"	2**	*a* x 2*b*, *p*	*b*	–
	2***	*a* x 4*b*, *p*	*b* $p_b mm$	yes
"	3	*a* x 3*b* *p*	*b* $p_b^{(3)}mm^{(2,1)}2^{(2,1)}$	–
"	3	*a* x 6*b* *p*	*b* $p_{b/2}^{(3)}mm2$	–
"	2	2*a* x *b*, *p*	*a*	–
	2***	2*a* x 2*b*, *p*	*a* $p_a mm$	yes
"	2	2*a* x 2*b*, *c*	diagonal	–
	2***	2*a* x 4*b*, *c*	diagonal $c_a mm$	yes
"	3	3*a* x 3*b*, *p*	diagonal $p_a^{(3)}{}_b^{(3)}2^{(2,1)}$	–

Notes:
a axis runs parallel to the long diagonals of diamonds.
b axis runs parallel to the short axis of diamonds, at 90° to the *a* axis.
Colour index indicates the number of alternating colours. Mesh size is expressed in terms of the fundamental, uncoloured periodicities. Wave-vector of a colour modulation wave is a vector perpendicular to the consecutive coloured rows; its length is equal to that of a complete colour permutation. Coloured plane groups are explained in the text.

* Expansion by intervening, neutrally coloured (in the observed cases white) stripes of lozenges parallel to the *a* axis always expands the *b* parameter by two fundamental *b* lengths.

** For the special case of a sequentially dichroic sequence, with the *a* axis expanded by the white diamonds of the first colouring stage, see text.

*** One more (neutral) colour, which is not counted into the colour index of the colour group, is present in the pattern.

coloured plane groups are summarised in Table 1. From the symmetrological viewpoint, only the three simplest combinations of flat-coloured and cross-hatched diamonds can be treated as one whole; artists might have done it for these simple cases as well:

a) The simplest colouring of the diamond pattern, in which both the flat-coloured and the cross-hatched components have only one colour each (Fig. 16a) can be described, as was done in the section on symmetry, by means of the dichroic plane group $p_c mm2$.

FIGURE 13. Bark painting by a member of the Madarrpa clan, 1975. Courtesy of H. Morphy.

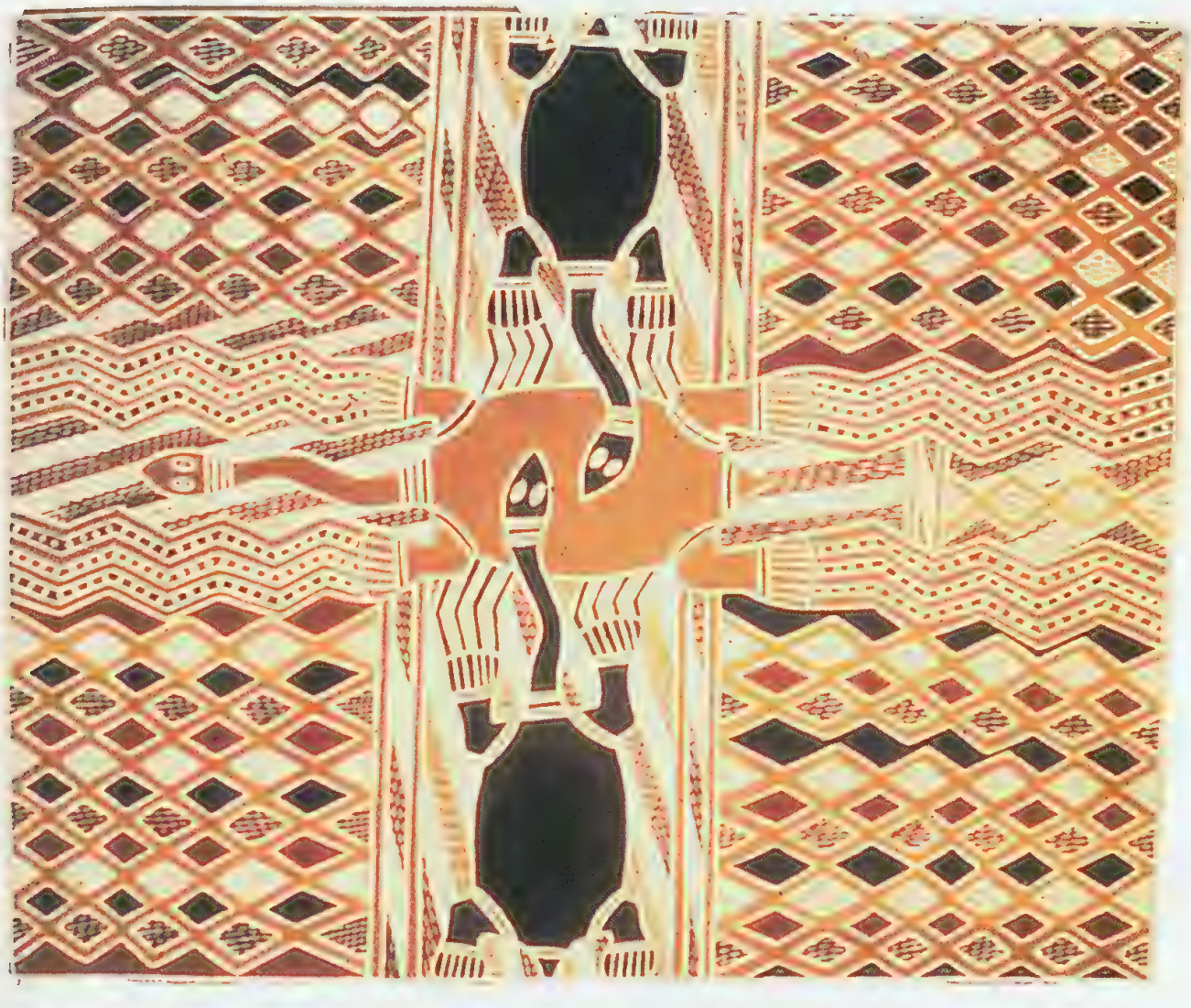

FIGURE 12. Bark painting by a member of the Dhalwangu clan, 1975. Courtesy of H. Morphy.

FIGURE 15. Bark paintings by a member of the Gumatj clan, 1975. Courtesy of H. Morphy.

FIGURE 14. Bark paintings by a member of the Gumatj clan, 1975. Courtesy of H. Morphy.

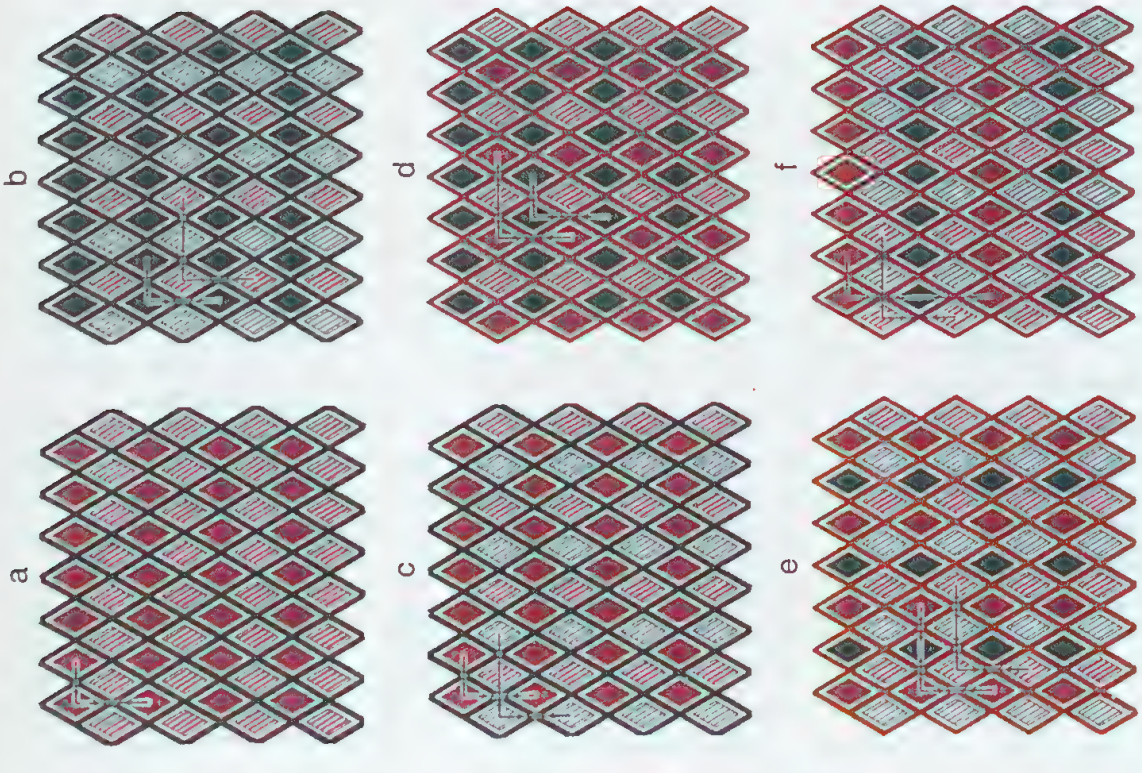

FIGURE 16. Observed colouring combinations for diamond patterns from the northeastern Arnhem Land. **a**, flat-coloured subset: *pmm*, cross-hatched subset *pmm*; full pattern $p_c mm2$ (Dhalwangu); **b–d**, different instances of *pmm* and $p_b mm2$ subsets, respectively; full pattern $p_b mm2$ (**b**, Madarrpa, **c**, Gumatj and **d**, Dhalwangu); **e**, both subsets $p_b mm2$, full pattern $p_b^{(2)}mm^{(2,1)}2^{(2,1)}$; **f**, $p_a mm2$ and $p_b mm2$, respectively.

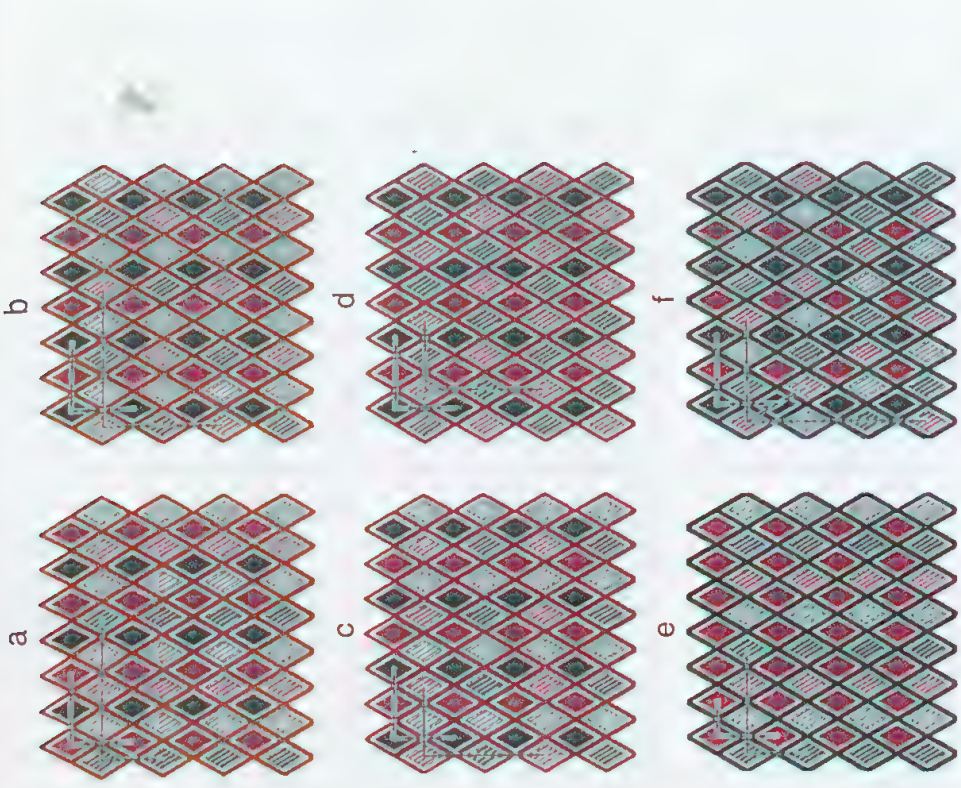

FIGURE 17. Further colouring varieties of diamond patterns from northeastern Arnhem Land. **a**, $p_b mm$ for a flat-coloured subset, $p_b mm$ with intervening colour-neutral white diamonds for a cross-hatched subset (Gumatj); **b**, $p_b mm$ and $c_a mm$, respectively, with intervening white colour-neutral diamonds (Dhalwangu); **c**, $p_b mm$ for the flat-coloured subset; $p_a mm$ for the non-white half of the cross-hatched subset (a sequentially dichroic cross-hatched sequence; Gumatj); **d**, $p_b mm$ and a 'dark' non-interspaced version of the cross-hatched subset with plane group $c_a mm$ (Gumatj); **e**, monochromatic *pmm* combined with three-coloured $p_b^{(3)}mm^{(2,1)}2^{(2,1)}$ (Gumatj); **f**, $p_b mm$, and $p_a{}_b^{(3)}{}^{(3)}2^{(2,1)}$ with a three-coloured wave (110) (ie wavefronts span the end of the *a* vector and the end of the -*b* vector of the unit mesh) (Gumatj).

b) A monochromatic pattern (Fig. 16b,c,d) (a x b) of the flat-coloured subset can be described by the uncoloured plane group $pmm2$. However, it can also be incorporated into the dichroic cross-hatched component (red- and white-hatched diamonds) of the pattern as its special positions on colour-changing mirror planes and 2-fold axes. The single flat colour can then be understood as a balanced mixture of two pure, hatched colours from general positions and therefore it does not change when translated by the colour-changing translation $b'/2$.

Thus, this pattern taken as a whole has the same dichroic symmetry, $p_b mm2$, as its cross-hatched portions. The colour-changing operators are the $b/2$ translation and the mirrors and 2-fold axes situated at $b/4$ and $3b/4$.

c) The only other pattern still described by a single unit mesh and symmetry group is the dichroic pattern in Figure 16e. In this pattern both components are colour-modulated, with the wave vector of the modulation parallel to the b axis. Each component taken alone would have symmetry $p_b mm2$, but the entire pattern (with the phase shift between the modulation of the flat-coloured and the cross-hatched components equal to 1/2 b of the underlying a x b lozenge pattern) has symmetry $p_b^{(2)}mm^{(2,1)}2^{(2,1)}$. None of the components is in a special position in respect to the coloured translation $b/2$.

For all other cases, amalgamation of the two components of the pattern into one whole either leads either to a significant loss of the symmetry information needed to describe the colouring schemes devised by the Aboriginal artist (especially the a x $2b$ modulation of the flat-coloured component), or yields unrealistically large repetition periods.

Therefore, separation of the two components of the pattern is natural to, and the only proper representation of, the colouring schemes designed by the Aboriginal painters. The contradiction of the two subsets creates a pleasant internal tension (large-scale shimmer) in the pattern, arrests the eye of the beholder and leads him to an intentional or unintentional analysis of the not too overloaded colouring scheme. The pleasure of the colour contrasts and of the recognition process is similar to that felt by beholders of good modern abstract paintings.

The majority of complex patterns in which the two-coloured subsets have unit cells of unequal size nearly always display the same mesh and symmetry for the flat-coloured red and black subset (a x $2b$) $p_b mm2$; the rare exception $p_a mm2$ is in Fig. 16f. The mesh size and coloured plane groups differ widely for the cross-hatched subset; it is primarily the sequences with dichroic symmetry that are observed. The dichroic plane groups $p_b mm2$, $p_a mm2$ (the colour change being perpendicular to that in the flat-coloured component in this case) or $c_a mm2$ (eg Fig. 17b) occur according to the direction of the colour-modulation wave. Most of them occur in an expanded version in which the b parameter of the unit mesh is expanded by the width of two colour-preserving ('neutral') white-hatched diamonds. The latter represent special positions between every consecutive, red–black and black–red pair of lozenges situated in general positions (Fig. 17a,b in the above sequence).

The highest colour index (number of alternating colours) observed for the cross-hatched component is three (a white–red–black repetition), with the colour modulation vector parallel to b. In Fig. 17e this unit mesh (a x $3b$), with the space group $p_b^{(3)}mm^{(2,1)}2^{(2,1)}$ is combined with the monochromatic flat-coloured mesh (a x b) $pmm2$.

More difficult is the case of white–black–red–white–red–black–white–black– (repeat) cross-hatched sequence attempted in the Gumatj painting in Fig. 2. The resulting b axis is a sextuple of the fundamental one: the $b/2$ parameter is three-coloured and the mirror plane perpendicular to b at 0 and 1/2 b is uncoloured, reflecting (ie reversing) the colour sequence. Thus, the complete description is $p_{(b/2)}{}^{(3)}mm2$.

In the already mentioned, rare, trichroic case from the Gumatj clan (Fig. 17f), the colour modulation wave is parallel to the diagonal of the fundamental uncoloured mesh. Its oblique mesh (a' x $3b$; $a' = a + b$ of the fundamental uncoloured mesh) has symmetry $p_b^{(3)}2^{(2,1)}$. If, as an alternative, the axes of the hatched pattern are selected as three-coloured sequences parallel to the axes of the flat-coloured mesh, the resulting coloured mesh is rectangular $p_a^{(3)}{}_b{}^{(3)}2^{(2,1)}$. The colour modulation vector, perpendicular to the diagonal modulation wave, is equal to $3b - a$ of the fundamental mesh.

The Used Versus Unused Symmetry Combinations

Even being limited only to the rectangular and oblique systems and ignoring, in agreement with

the Aboriginal artists, the additional colouring possibilities which arise in the case when diamonds turn into squares and the underlying pattern belongs to the square system, comparison of the possible colouring schemes (plane groups) with the actually used ones reveals the very restricted choice the Aboriginal artists have made.

As we have seen, the fundamental uncoloured (or one-coloured) lozenge sets have symmetries *cmm*, *pmm*, *pgg*, *pgm* or *p*2. From the first two plane groups, the following categories of dichroic plane groups with unchanged basic translation vectors can be derived: *cm'm*, *cm'm'*, $p_C gg$, $p_C mm$ and $p_C gm$ from *cmm*, and *pm'm* and *pm'm'* from *pmm*. For a doubled *a* parameter, the plane groups $p_a mm$, $p_C mg$ (and their permutation for the doubled *b* parameter), and for doubled *a* and *b* parameters $c_a mm$, can be added. Some of them are illustrated in Figs 7–9, 16 and 17, and the remaining ones can be found in Washburn & Crowe (1998). Whereas $c_a mm$ and $p_a mm$ (or its rotated version, $p_b mm$) can occur both with whole diamonds of one colour or with diamond halves coloured oppositely, some of the symmetry groups require symmetric division of each diamond into two or four oppositely coloured portions (Figs 7, 8). As a rule, such division (known, eg, from the Acoma Pueblo pottery (New Mexico), Mehinaku and other tribes in Brazil, and Turkoman carpets of Central Asia) was almost never attempted by the Aboriginal artists. Thus, all groups with colour-changing mirror planes (which may not transpire from the group symbol because it only shows the colour-preserving *g* planes parallel to them) fall out and we are left with just the three rectangular plane groups of symmetry described from bark paintings, ie $p_a mm$ ($p_b mm$), $p_C mm$ and $c_a mm$ (Figs 7, 9). The only exception, which has colour-changing mirror planes, is the occurrence of the overall dichroic group $p_b^{(2)}mm^{(2,1)}2^{(2,1)}$ (Fig. 16e) mentioned above. It is based on the uncoloured group *pmm*, and the lozenges in the central horizontal row of its mesh are non-equivalent to those situated on the *a* and *b* vectors. It might be better to divide this pattern into two independent components, both with symmetry $p_b mm$, in line with the other patterns of the series and, perhaps, in agreement with the understanding of its structure by the artist himself.

The trichroic plane groups used by Aboriginal artists are only of the simplest type. They are based on a juxtaposition of colour stripes that results in a unidirectional colour modulation (ie periodic colouring) of the underlying geometric pattern. Beside the cases when the modulation vector is parallel to the axes of the fundamental mesh (Fig. 17e), the above mentioned more complicated case of diagonal waves has been worked out by the Gumatj artist (Fig. 17f). However, the corpus of potential, but unused, trichroic combinations is large.

Discussion and Conclusions

The present study has examined the applicability of more exact crystallographic methods to Aboriginal art studies. Its preliminary results were summarised in the general paper by Makovicky (1986) and presented in Perth in 1987. Since then, some concepts have been revised and new material added.

The advantages of using plane groups of symmetry for analysis of larger bodies of ornaments are indisputable today (Abas & Salman 1995; Makovicky 1989; Makovicky & Makovicky 1977; Makovicky & Fenoll 1997). The description of coloured ornaments by means of dichroic or polychromatic groups of symmetry is less widespread but equally effective (Makovicky 1986; Makovicky & Fenoll 1999; Washburn & Crowe 1998:63). On the one hand it gives a short-hand notation for the colouring schemes applied, and on the other it allows the identification of colouring sequences built on the same principle, notwithstanding the colour combinations or element shapes used. For example, the Aboriginal colour sequences red–white, black–red and red–yellow are described by the same dichroic plane group (Fig. 16e,f), expressing the same colouring intention as well. Dichroic or polychromatic groups of symmetry are the best tool for further analysis of distinct sequences based on the same underlying pattern, as in the present case.

Symmetrological analysis shows that black, red and ochre yellow always play a role in colour alternation/permutation in Aboriginal patterns, whereas the role of white is varied. It is not used as a flat colour; in its cross-hatched form it either represents yet another regular colour (in sequences such as red–white, black–red–white– (repeat) (Fig. 17e) or red–yellow–white– (repeat)) or it is the neutral colour interspaced in colour sequences, in principle dichroic, such as white–red–white–black–white– (repeat), eg Fig. 17a. The latter case can also be interpreted as a sequentially dichroic sequence in which the cross-hatched subset is divided into a white and a non-white subset; the latter subset is further divided into two distinctly coloured subsets of diamonds. The second

colouring step can take more fanciful forms — it can be centred, as in Fig. 17b, or periodic at a right angle to the first step, as in Fig. 17c. The rare occurrence of these sequences in Aboriginal paintings is in contrast to their common occurrence elsewhere (Makovicky 1986; Makovicky & Fenoll 1999).

Lack of green and blue earthy pigments undoubtedly contributed to the four-colour palette and colour sequences of Arnhem Land artists. Another technical limitation which might have played a role in the choice of colouring schemes/sequences (coloured plane groups) is the size of bark surfaces available and of the fields into which they were traditionally divided.

The symmetrological results of the present study are satisfactory: the artistic canon of the Yirritja diamond patterns can be successfully and exactly described by means of coloured symmetry groups and colour modulation waves. However, the number of bark paintings available for this study does not allow us to reach the other goal of this investigation, that of potentially associating the distinct colouring schemes with different clans of the Yirritja moiety. However, the present investigation has defined all the necessary means for such a follow-up study based on detailed investigations in the field and in museum collections.

What are the preliminary results obtained from the limited material? At present, it appears that the Dhalwangu clan uses preferably one- and two-coloured sequences, resulting in the plane groups shown in Fig. 16a,c–f; one suggestion of a *pmm*/$p_b^{(3)}mm^{(2,1)}$ combination (as in Fig. 17e) was seen. The version in Fig. 17a with interspaced white cross-hatch is important, both in the red–black and red–yellow varieties.

The Madarrpa clan uses similar simple patterns, such as those in Figs 16b,c,e and 17a. However, in the work of Wakuthi Marawili in 1982, the palette explodes into a spectrum of $p_b^{(3)}mm^{(2,1)}2^{(2,1)}$ sequences for both the flat-coloured and the cross-hatched subsets. Placing the 'starting' block of one subset next to that of the other subset and running the colour permutations in the same directions in both subsets, a very effective colour scheme has been devised (Caruana 1994: Fig. 56). A combination of the same flat-coloured 3-fold sequence as above with a two-coloured white-interspaced cross-hatched sequence $p_b mm$ rims this bark painting. The same artist created a panel with patterns such as those in Figs 16e and 17d for the Berndt Museum of the University of Western Australia.

The Gumatj bark paintings contain the most complicated examples of colouring. Starting with a monochromatic flat-coloured subset, patterns in Figs 16a,c and 17e (with stacking faults in the colouring sequence) are observed. With a bi-coloured flat-coloured subset, powerfully coloured versions of Figs 16e and 17a were designed; well used also is the pattern of Fig. 17c with the two colour-modulation directions at right angles to each other. The chessboard-based pattern of Fig. 17d is accompanied by imperfect versions of the patterns of Fig. 17b,f. A particular type of pattern reproducing that of a crocodile's back is in Fig. 11. Faults in three-coloured cross-hatched sequences are frequent, sometimes making the interpretation of the depicted panels ambiguous.

Patterns with partitioned diamonds are infrequent. A rare example with the black flat-coloured subset possessing a longitudinal partition and constructed according to the schemes in Fig. 16a,c, and a pattern similar to that of Fig. 17a, but with one-coloured flat-coloured elements, comes from the Munyuku clan (Morphy 1979: 304).

Only rare examples were seen of diamond patterns with diagonally or parallel three-striped diamonds. A faultless *p*2' pattern of this type was painted by J. Wululu, central Arnhem Land (Yirritja, in Caruana 1994); a mixture of *p*2' (even p_b.2), and *pgm'* (due to faults in colour sequence) from Gupapuyngu clan (Milingimbi, Arnhem Land, 1963) is reproduced by Cooper et al (1981). A similar mixture of *p*2' and p_b.2 is found in a Gumatj pattern (Fig. 1) from 1959–60; and a faultless combination of flat-coloured (dotted) *pmm* and cross-hatched *p*2' in a Gupapuyngu (1948) pattern, both photographed by H. Morphy. Apparently, these examples are fairly marginal to the entirely cross-hatched striped sequences of other clans, eg Marrakulu, Manggalili, Rirratjingu (Morphy 1981: 63; Caruana 1994: 64–67), as well as of those from central Arnhem Land.

Although the amount and breadth of material studied limits severely the validity of our conclusions, it appears that there exist observable clan-specific differences in the latitude of designs used. However, they are easily transcended in the production of especially talented bark painters, such as W. Marawili of the Madarrpa clan. Without doubt, the largest frequency of complex designs occurs in the paintings by members of the Gumatj clan. To the contrary, the Dhalwangu creators of exceptionally powerful turtle paintings used their basic pattern language to a great advantage without complicating it by more complex colour schemes.

How old are the diamond designs? Old examples are rare; the Dhalwangu example from 1952 (Sutton 1990: 21) contains the same colouring combinations (coloured plane groups) as the new paintings (Figs 16a,c,e). Other Dhalwangu examples from 1948 contain the same patterns. Gumatj painting from 1959 to 1961 contains a pattern of the Fig. 16c type. The assertion is that the coloured diamond patterns are traditional (Morphy 1981: 62) and may have had their origin in contacts with Macassan trepang fishermen who brought Indonesian utilitarian art (eg patterned fabrics) with them (Mulvaney 1981: 16). The symmetrological independence of the northeastern Arnhem Land diamond patterns, and of their colouring, from the original Macassan examples is apparent from a perusal of Indonesian textile patterns, which are largely based on symmetries other than those used by Arnhem Land artists.

From a symmetrological point of view, the majority of studied Aboriginal coloured diamond patterns have a unique character. In several cultures a dichroic division of elements into a white and a coloured subset was common, with the former left intact and the latter again divided into two differently coloured subsets. These patterns were defined as sequentially dichroic by Makovicky and Fenoll (1999); examples from different cultures (especially Islamic and Old Egyptian) are given in Makovicky (1986). The Arnhem Land Aborigines acted differently in most instances. With the exception of the simplest patterns, illustrated in Fig. 16b–d, both of the two primary subsets (ie the flat-coloured and the cross-hatched) are further dichroically or trichroically subdivided. Only the cross-hatched sequences in Fig. 17a–c, with rows of white 'colour-neutral' diamonds, were produced by the process of sequentially dichroic colouring.

In conclusion, with powerful dichroic and trichroic sequences, Aboriginal artists created a unique dynamic whole in which the two different periodicities produce a captivating internal tension and a wonderfully shimmering colour effect. The overall impression can be described as two quite different colour waves transcending the same complex pattern. They are in contrast to the simple colouring of the animals, persons and objects that supply the narrative of the painting.

Acknowledgments

This contribution was made possible by the generosity of Prof. Howard Morphy (Australian National University, Canberra) who shared with the author his photographic material on bark paintings from Arnhem Land. Professional help by Mrs Britta Munch, Mrs Camilla Sarantaris and Mr Ole B. Berthelsen (University of Copenhagen) was highly appreciated. The South Australian Museum kindly covered the publication expenses; Dr Allan Pring and Dr Barry Craig of that Museum were instrumental in organising this publication.

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SHALLOW-WATER CUMACEAN CRUSTACEA FROM AUSTRALIA AND LOMBOK (INDONESIA): FAMILIES BODOTRIIDAE AND LEUCONIDAE

U MÜHLENHARDT-SIEGEL

MÜHLENHARDT-SIEGEL, U. 2003. Shallow-water cumacean Crustacea from Australia and Lombok (Indonesia): families Bodotriidae and Leuconidae. *Records of the South Australian Museum* 36(1): 21–57.

Twenty species are identified from the families Bodotriidae and Leuconidae from 39 shallow-water stations around Australia and one location in Indonesia. Of these 20 species, two are possibly conspecific. One species of the genus *Leptocuma* has to stay in open nomenclature because of the poor condition of the specimen. The genus with the most species is *Cyclaspis* with 11 representatives in the samples. Two of them, *Cyclaspis ursulae* sp.n. from the *exsculpta*-group and *Cyclaspis lissa* sp.n., are new to science; *Cyclaspis strumosa* and *C.* cf. *strumosa* are also discussed. A new species of the genus *Mossambicuma* is described. This genus has been monotypic since Day (1978) described it from the western Indian Ocean. New species are also described for the genera *Leptocuma*, *Glyphocuma*, *Picrocuma* and *Bodotria*. Only one representative of the family Leuconidae was found, in Tasmania, extending the distribution of that species, *Ommatoleucon ocularis*.

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Following the comprehensive studies of Herbert Hale from 1928 to 1952 (Hale 1928, 1936, 1937, 1944, 1945, 1948, 1952) on Cumacea from Australia, very little work was done on these Crustacea in this region until Tafe & Greenwood (1996) did their investigations at Moreton Bay, Queensland.

The family Bodotriidae comprises 31 genera, five of them endemic to Australian waters. The Bodotriidae genus with the most species is *Cyclaspis* with 118 species, many (46%) of them described from Australia. Despite the comprehensive and intensive studies of the authors mentioned above, even more undescribed species remain. The descriptions of two of these are given here. For detailed generic diagnosis and subdivision of the genus see Tafe & Greenwood (1996) and for synonyms see Bacescu (1988).

The other genera mentioned in this study are *Bodotria* (Atlantic, Indian and Pacific oceans), *Leptocuma* (Australia and West Atlantic), *Mossambicuma* (Western Indian Ocean, Mozambique), *Glyphocuma* (Australia), *Picrocuma* (Australia) from the family Bodotriidae and *Ommatoleucon* (Australia) from the family Leuconidae.

Material And Methods

Material collected in shallow coastal waters using a hand net by Prof. Dr. G. Hartmann and Dr. G. Hartmann-Schröder during their expedition to Australia September 1975 to February 1976:

Western Australia

WA sample 10, Broome, 10 September, fine sandy eulitoral

WA samples 14+15, Broome, close to Willie Creek

WA samples 17+18, Derby, 20 September, silty lower eulitoral

WA sample 23, Broome, 24 September, mangroves

WA sample 27, Port Hedland, 27 September, close to low tide, fouling

WA sample 28, Port Hedland, 27 September, fine sand on reef top

WA sample 30, Port Hedland, 28 September, silty clay, mangroves

WA sample 35, Port Samson, 30 September, sand and algae, coarse sand and mud

WA sample 37, 7 km east of Dampier, Horsines Cove, 2 October, shell hash – sand, mangroves

WA sample 39, Dampier, 3 October, fine sand eulitoral, in front of tidal flat edge

WA sample 46, 24 km south of Exmouth, 10 October, fine sand, eulitoral, between reefs

WA sample 66, Drummonds, close to Geraldton, 21 October, fine sand

WA samples 67+68, Jurien close to Cervantes, 24 October, sand

South Australia

SA sample 126, Port Lincoln, Proper Bay, 4 December, sand and seagrass
SA sample 129, Port Augusta, 6 December, mangroves, silt and shell hash

Victoria

VIC sample 148, Foster, Port Welshpool, 28 December, mangroves, soft silty sand
VIC sample 165, southern dead end of Clarence River, near Yamba, 18 January 1976, brackish water and mangroves.

Additional unidentified material was available from the South Australian Museum, Adelaide:
Various stations, Noosa R., 40 mesh tow net, June 1940, leg. ISR Munro;
Whiting Ground, Waterhouse Bay, east end Thistle Island, 4 March 1931, 8 – 8.3 fathoms;
North end Herald Bight, Shark Bay, 3 fathoms, sand, 'Isobel' W.H., 21 November 1945, submarine light, temperature: 24.22° C;
Whalers Bay, Thistle Is., 3 February 1941, submarine light, leg. K. Sheard;
Near Pt. Maclaren, Thorny Passage, Whiting Ground, 3.5 fathoms, 8–8.30 pm, 2 March 1941, submarine light, leg. K. Sheard.

Material collected by Dr. V. Siegel and the author, shallow subtidal water:

Tasmania

TAS Nubeena, 6 November 1995, soft silty sand with detritus
TAS Marion Bay, 5 November 1995, fine sand and sea grass

Queensland

QLD, Lizard Island 1992:
11 November, mangroves, 0.1 m, soft sand
12 November, Turtle Bay, 15 m, sand
13 November, sand, 10 m
14 November, Turtle Bay, 16 m, coarse sand
15 November, Turtle Bay, 15 m, soft sand
17 November, Mermaid Bay, 7–10 m
17 November, sand, 7 m
18 November, North Reef, 19 m, sand
19 November, Lagoon, 7 m, sand
19 November, Watson's Bay, 17 m, sand
19 November, sand, 2 m
20 November, Pidgin Point, 12 m
20 November, Watson's Bay, 16 m
21 November, South Reef, 12 m

Material collected by Dr. J. Martens and Dipl. Biol. U. Heuer:
Indonesia, Lombok, Plankton/Neuston, 9 March 1996, 0–10 cm.

The material is deposited at the Zoological Museum of the University of Hamburg (ZMH) or in the South Australian Museum, Adelaide (SAM).

Systematics

Order CUMACEA Kröyer, 1846

Family BODOTRIIDAE T. Scott, 1901

Subfamily BODOTRIINAE T. Scott, 1901

Genus ***Bodotria*** Goodsir, 1843

Bodotria* cf. *biplicata Gamô, 1964
(Figure 1)

Material
Lombok: 1 juvenile male; ZMH K 39930.

Remarks
The juvenile male (1.5 mm in length) has the pleopods barely developed; the total length is about half as long as the holotype (2.7 mm). Its two lateral carinae and the dorsomedian carina are well marked in the anterior half, the pitted structure of the carapace makes the individual similar to *B. pulchella* (Sars, 1878). It is differentiated from *B. pulchella* by the unsegmented uropod's endopod, which makes it likely to be conspecific with *B. biplicata*.

Distribution
Japan, Korea and Indonesia.

Bodotria* cf. *minuta Kurian, 1961
(Figure 1)

Material
Lombok: 1 juvenile female; ZMH K 39929.

Remarks
The juvenile female in the collection has the uropods' rami missing. It fits quite well with Kurian's (1961) description: carapace without carinae, first free pereionite small, in the present female not as free as in adult female, pigment spots present, as figured by Kurian.

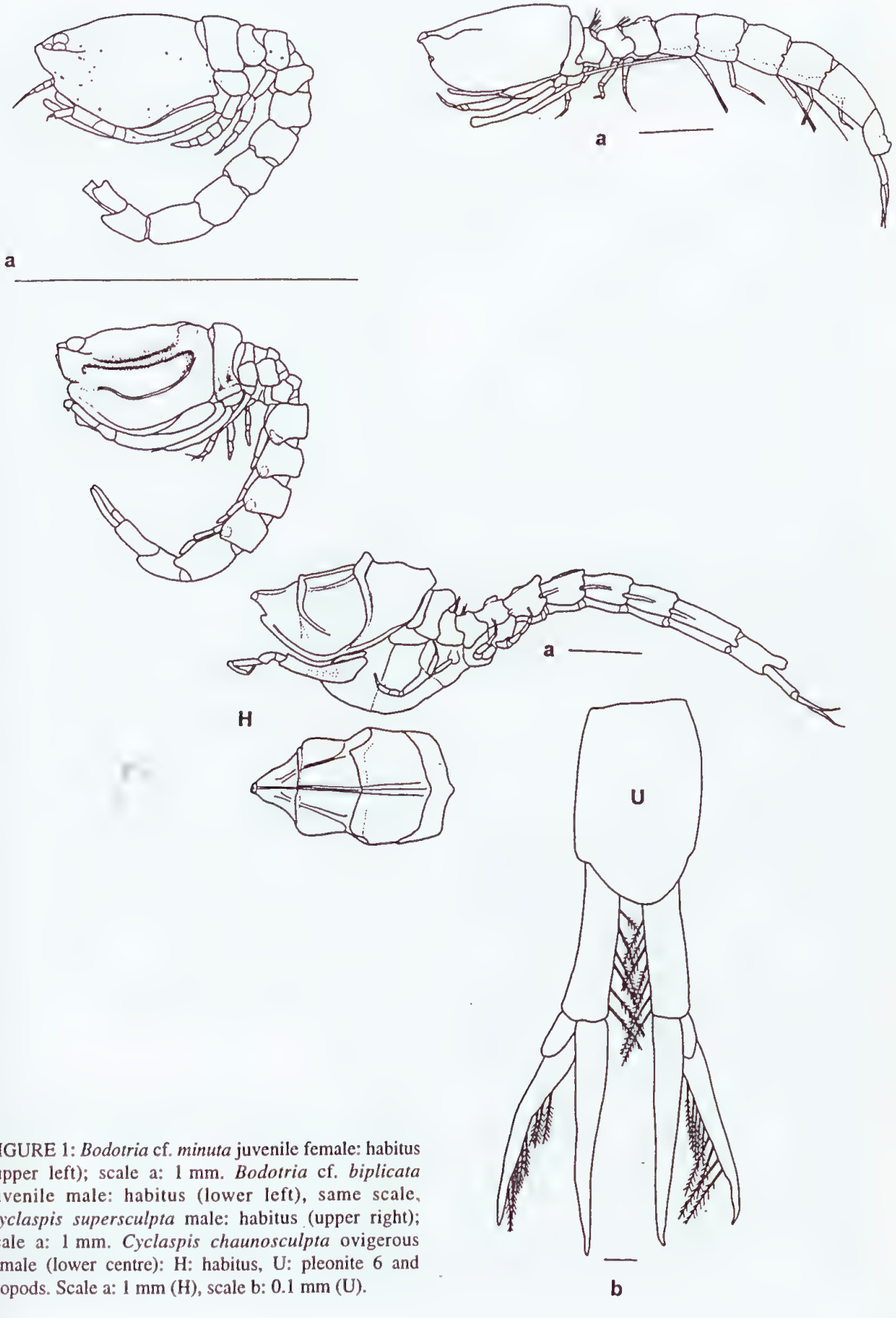

FIGURE 1: *Bodotria* cf. *minuta* juvenile female: habitus (upper left); scale a: 1 mm. *Bodotria* cf. *biplicata* juvenile male: habitus (lower left), same scale. *Cyclaspis supersculpta* male: habitus (upper right); scale a: 1 mm. *Cyclaspis chaunosculpta* ovigerous female (lower centre): H: habitus, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (U).

Distribution

Southern India and Indonesia.

Bodotria unacarina sp.n.

(Figures 2 and 3)

Material

WA: 35: 1 subadult male, 1 subadult female, 1 juvenile.

QLD: Lizard Island 1992: Turtle Bay (15 November, 15 m): 2 juvenile females; Pidgin Point: 1 subadult male, 1 juvenile female; ZMH K 39931; sand (2 m): 3 ovigerous and 2 subadult females, 1 male, 10 juveniles; SAM C 5996.

Holotype: ovigerous female SAM C 5995a, SAM C 5995b: extremities of paratype

Paratypes: 2 ovigerous females, 2 subadult females, 1 male (dissected), SAM C 5996

Leg.: V. Siegel & U. Mühlenhardt-Siegel

Date: 19 November 1992

Locus typicus: Australia, Great Barrier Reef, Lizard Island, sand (2 m).

Diagnosis

Bodotria with one lateral carina in female, uropod's endopod unsegmented, 11 and one terminal setae on endopod in male, two median and one terminal setae in female, no scaly structure on carapace, uropod's peduncle longer than endopod in male.

Description

Based on holotype, ovigerous female, 2.2 mm length in total:

Carapace with a dorsomedian carina and one lateral carina on each side, proportion length to height 1.6, length to width 1.2. Pseudorostrum shorter than length of ocular lobe; siphonal tube moderately long; dorsomedian line straight; antennal notch narrow; anterolateral margin smooth.

Integument granulose; eyes with six lenses. First free thoracic segment not visible, the second pedigerous segment longer than following, free segments combined shorter than carapace, lateral carina continued on second pedigerous segment, third to fifth segment with lateral plates.

Abdomen 1 mm in length, a little shorter than carapace and free thoracic segments combined, pleonite 6 proportion length to width 1.2.

Description of extremities is based on paratype, ovigerous female:

First antenna geniculated, basal article longest, middle article shortest, main flagellum two-segmented, distally with two aesthetascs and one seta, accessory flagellum rudimentary, only three setae visible; mandible pars incisiva with three teeth, between pars incisiva and pars molaris 11 setae.

Maxilliped 2 long basis, merus outer margin dilated, carpus and propodus equal in length, longer than merus, dactylus with stout terminal seta; maxilliped 3 basis longest article, with short distal prolongation, not reaching articulation between ischium and merus; ischium longer than merus, merus with short terminal prolongation, carpus distally geniculated, propodus and dactylus subequal in length, terminal seta stout, exopod present (not figured).

Pereiopod 1 basis longer than rest of extremity, carpus second longest article, propodus and dactylus subequal in length, dactylus half as wide as propodus, exopod present; pereiopod 2 basis longer than rest of extremity, covered with hair-like setae, ischium missing, merus and carpus equal in length, propodus short, dactylus tapering with one terminal and two subterminal setae; pereiopods 3 to 5 similar in shape, the hinder extremities getting shorter due to diminishing length of basis; uropod's endopod unsegmented, one long and one short seta at inner margin, one terminal seta, peduncle longer than pleonite 6 (length proportion 1.7) and endopod (length proportion 1.6), exopod a little shorter than endopod.

Male with five pairs of well developed pleopods, 2.8 mm in length, abdomen longer than carapace and free thoracic segments combined, pseudorostral lobes meeting in a point in front of ocular lobe, abdominal segments larger than in female; proportions of peduncle to pleonite 6 is 1.1, peduncle to endopod 1.2, pleonite 6 length to width 1.4. Bases of first two pedigerous extremities longer than in female, uropod's peduncle with ten long and seven shorter setae, endopod with nine spine at inner margin, additional one terminal and one subterminal spine, exopod with 11 long plumose setae at inner margin and one strong terminal seta.

Etymology

The new species is named after its most striking morphological character, the single lateral carina.

Remarks

Bodotria species with unsegmented uropod's endopod, one lateral carina, and proportion of pleonite 6 length to width close to 1.2, as in the new species are: *B. arenosa* (Goodsir, 1843) from the northeastern Atlantic; *B. armata* Tafe &

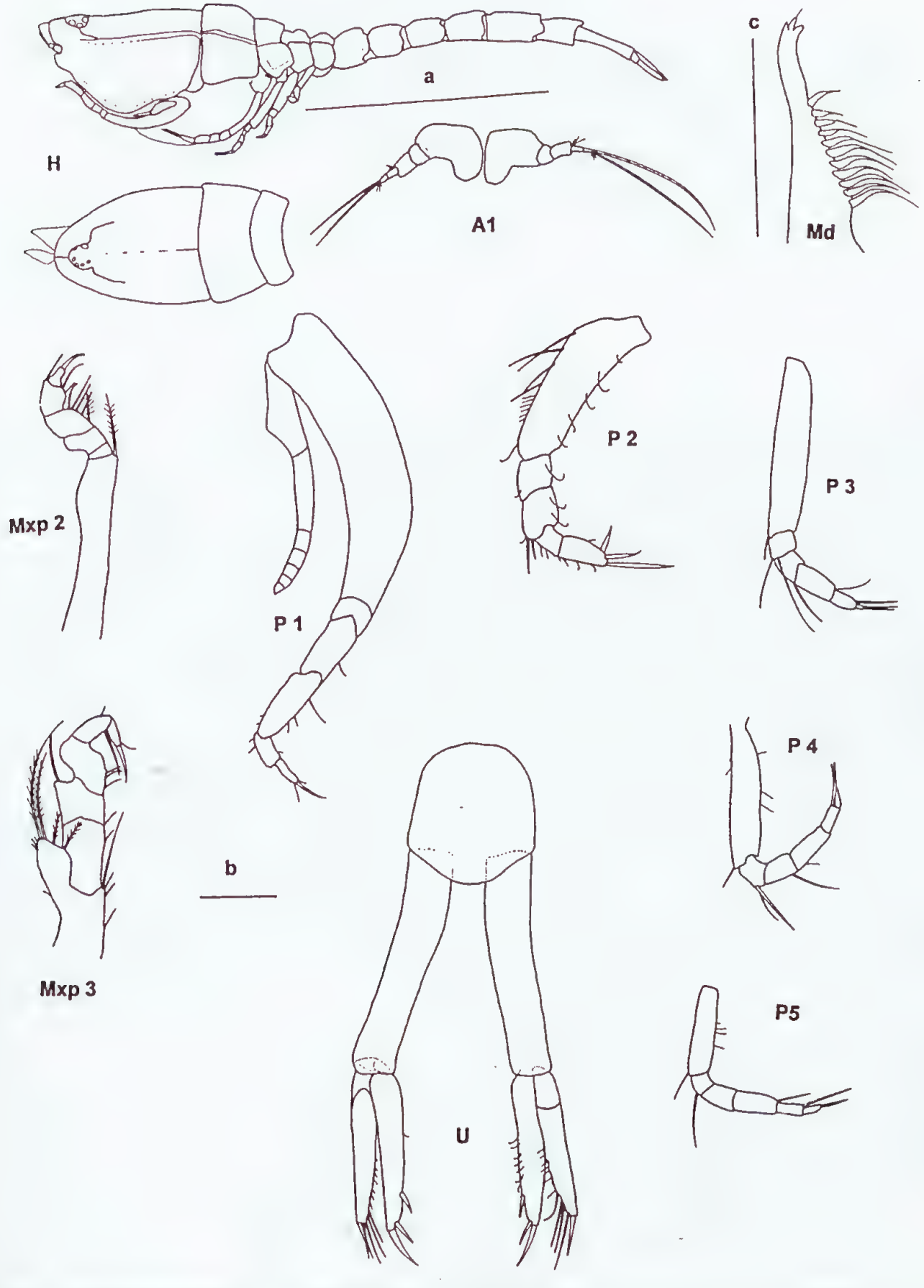

FIGURE 2: *Bodotria unacarina* sp.n. ovigerous female: H: habitus female, A1: first antenna, Md: mandible, Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (A1, Mxp2, Mxp3, P1, P2, P3, P4, P5, U), scale c: 0.1 mm (Md).

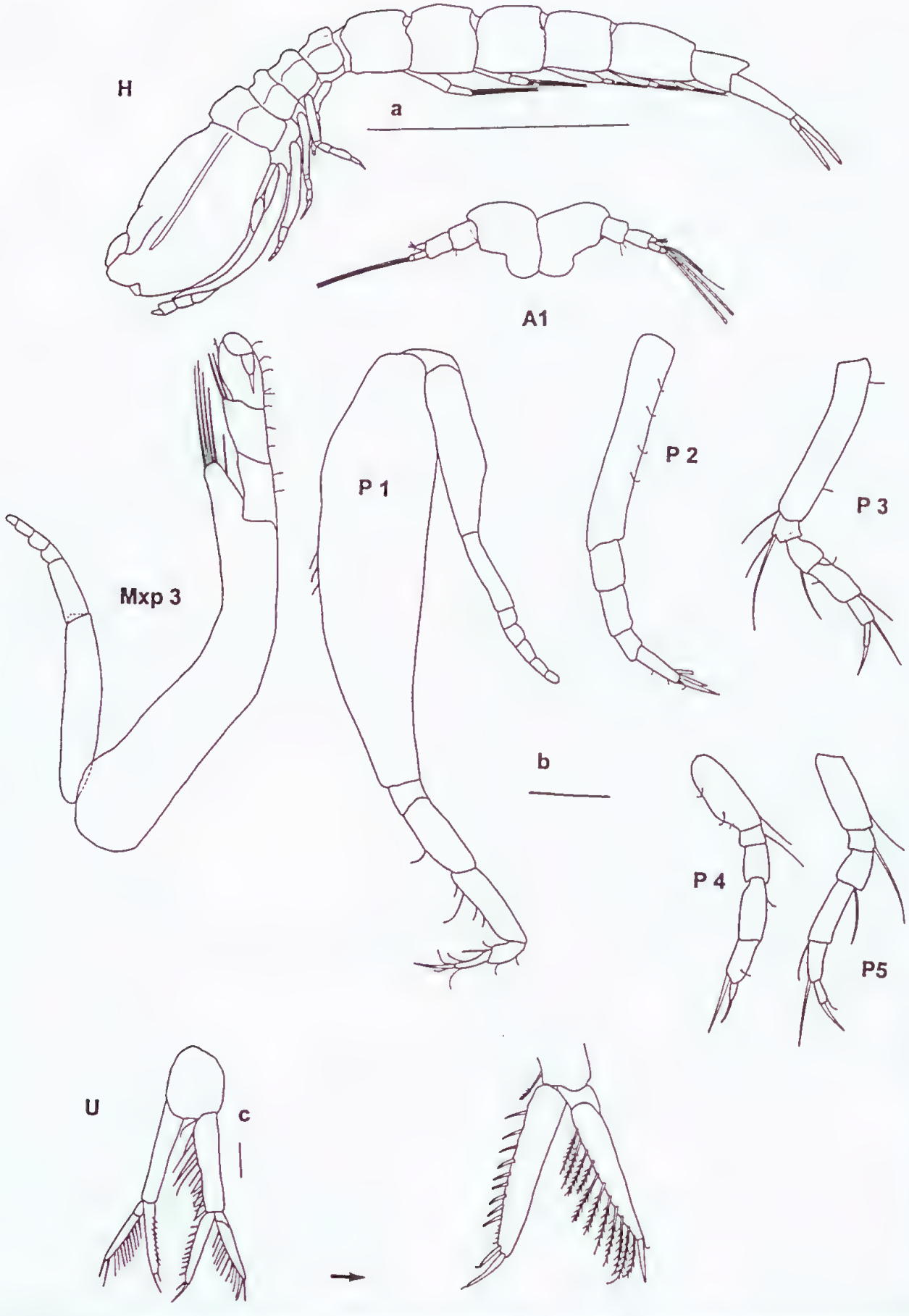

FIGURE 3: *Bodotria unacarina* sp.n. adult male: H: habitus, subadult male A1: first antenna, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (A1, Mxp3, P1, P2, P3, P4, P5, U enlarged), scale c: 0.1 mm (U).

TABLE 1: Comparison of some characters of selected *Bodotria* species with unsegmented uropod's endopod, n.d.: no data.

	Bodotria arenosa	*Bodotria armata*	*Bodotria armata*	*Bodotria rugosa*	*Bodotria serrata*	*Bodotria unacarina* n.sp.	*Bodotria unacarina* n.sp.
sex	male	female	male	female	male	female	male
lateral carina	1	1	1	1	1	1	1
Proportions							
pleonite 6 length:width	1.3	1.2	1.2	1.3	1.1	1.2	1.4
peduncle:pleonite 6	1.7	1.5	1.6	1.2	2.5	1.7	1.1
peduncle:endopod	1.5	1.4	n.d.	1.2	1.6	1.6	0.9
pedigerous segment visible?	–	?	?	+	?	–	–
setae at endopod	4+1	?	11+1	2+2	13+2	2+1	11+1

Greenwood, 1996 from Moreton Bay, Queensland; and *B. rugosa* Gamô, 1963 and *B. serrata* Harada, 1967 from Japan (Table 1). The new species resembles *B. arenosa* with respect to the females' length proportions of the uropod's peduncle to pleonite 6 and endopod, respectively. It differs from that species in the number of setae on the endopod. The new species differs from the geographically close species *B. armata* in missing the scaly structure of the integument, and the length proportions peduncle to endopod and to pleonite 6. The female's length proportion of peduncle to pleonite 6 is 1.5 in *B. armata* and 1.7 in *B. unacarina* sp.n., and the proportion of peduncle to endopod is 1.4 in *B. armata* and 1.6 in *B. unacarina* sp.n. The male's length proportions of peduncle to pleonite 6 are 1.6 in *B. armata* compared to 1.1 in *B. unacarina* sp.n. The differences between females of the new species and *B. rugosa* are the relatively longer uropod's peduncle relative to pleonite 6 and endopod in the new species. The differences between males of the new species and *B. serrata* is the relatively shorter uropod's peduncle.

Genus *Cyclaspis* Sars, 1865

Cyclaspis caprella Hale, 1936
(Figure 4)

Material

TAS: Nubeena: 1 subadult, 2 ovigerous females; ZMH K 39917.

Remarks

Hale (1936) described the male of his new species from Yorke Peninsula, South Australia, and emended the description for the males from the same location (Hale, 1944). He mentioned the females (Hale, 1944) and gave a short description and a few figures of the females from Kettering, Tasmania (Hale, 1948). Additional figures of the females' extremities are given herein. The species is easily identified by the anterior 'horns' formed by the acute anterolateral corners, narrow ocular lobe with terminal eye, pseudorostral lobes not meeting in front of the ocular lobe, strongly elevated second pedigerous segment, fourth and fifth pedigerous segments with a pair of triangular teeth on dorsum, the first pleonite with a strong procurved tooth on each side near the dorsal posterior end. The uropod's exopod has two apical mucrones, as mentioned by Hale (1944).

Cyclaspis chaunosculpta Tafe & Greenwood, 1996
(Figure 1)

Material

QLD: Lizard Island 1992: Lagoon (7 m): 1 female with developed oostegites; ZMH K 39920.

Remarks

The habitus of the specimen fits quite well with the figure in Tafe & Greenwood (1996). Additionally, pleonite 6 and uropods are figured (Fig. 3). The carapace structure of the Lizard Island specimens seems to have smaller sponge-like pits than in the Moreton Bay specimens.

Cyclaspis cottoni Hale, 1937
(Figure 5)

Material

TAS: Marion Bay: 3 ovigerous females, 4 adult and 5 subadult males; SA: 126 (Port Lincoln): 1

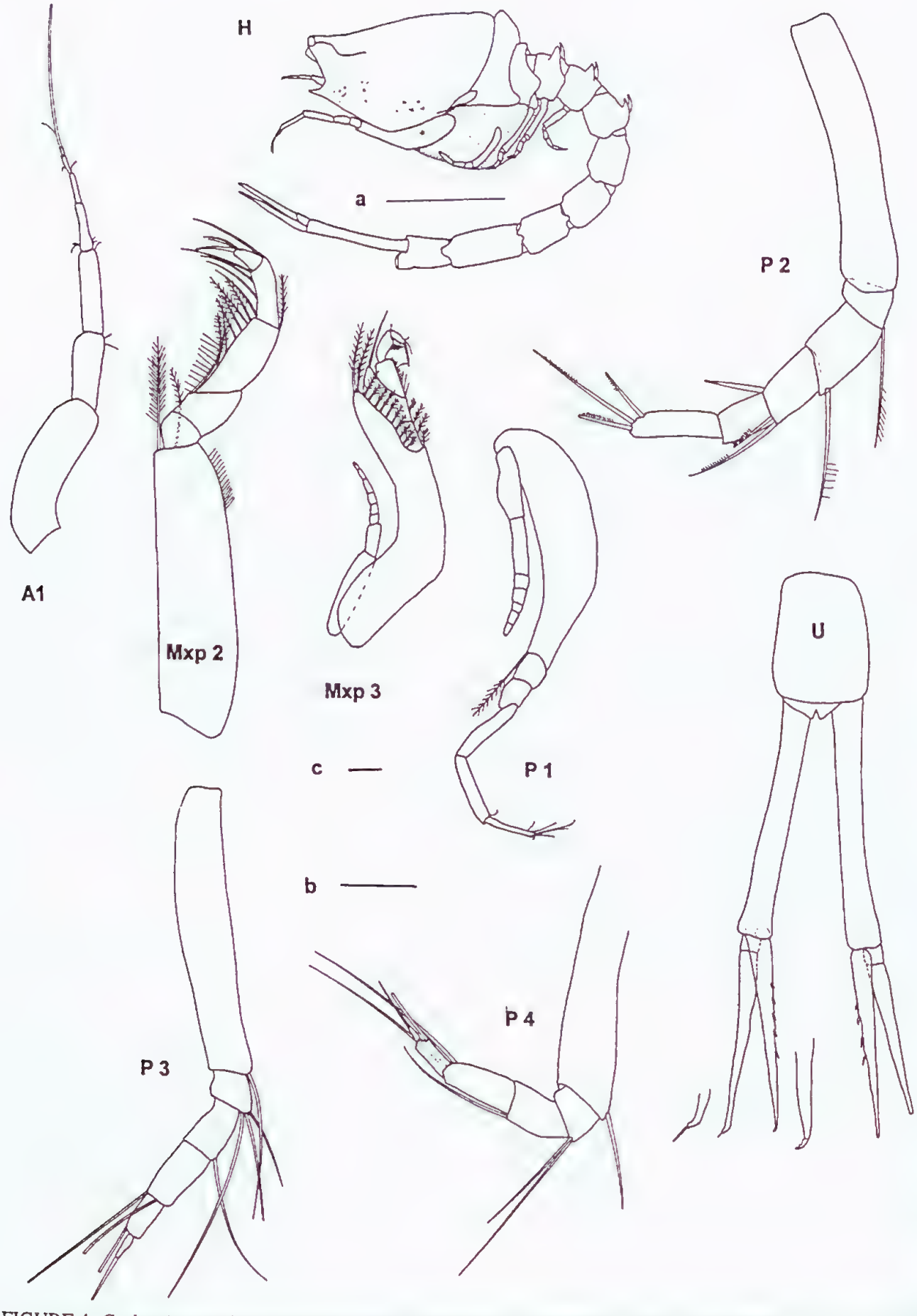

FIGURE 4: *Cyclaspis caprella*, ovigerous female: H: habitus, A1: antenna 1, Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1 to P4: pereiopod 1 to 4, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (A1, Mxp2, P2, P3, P4), scale c: 0.1 mm (Mxp3, P1, U).

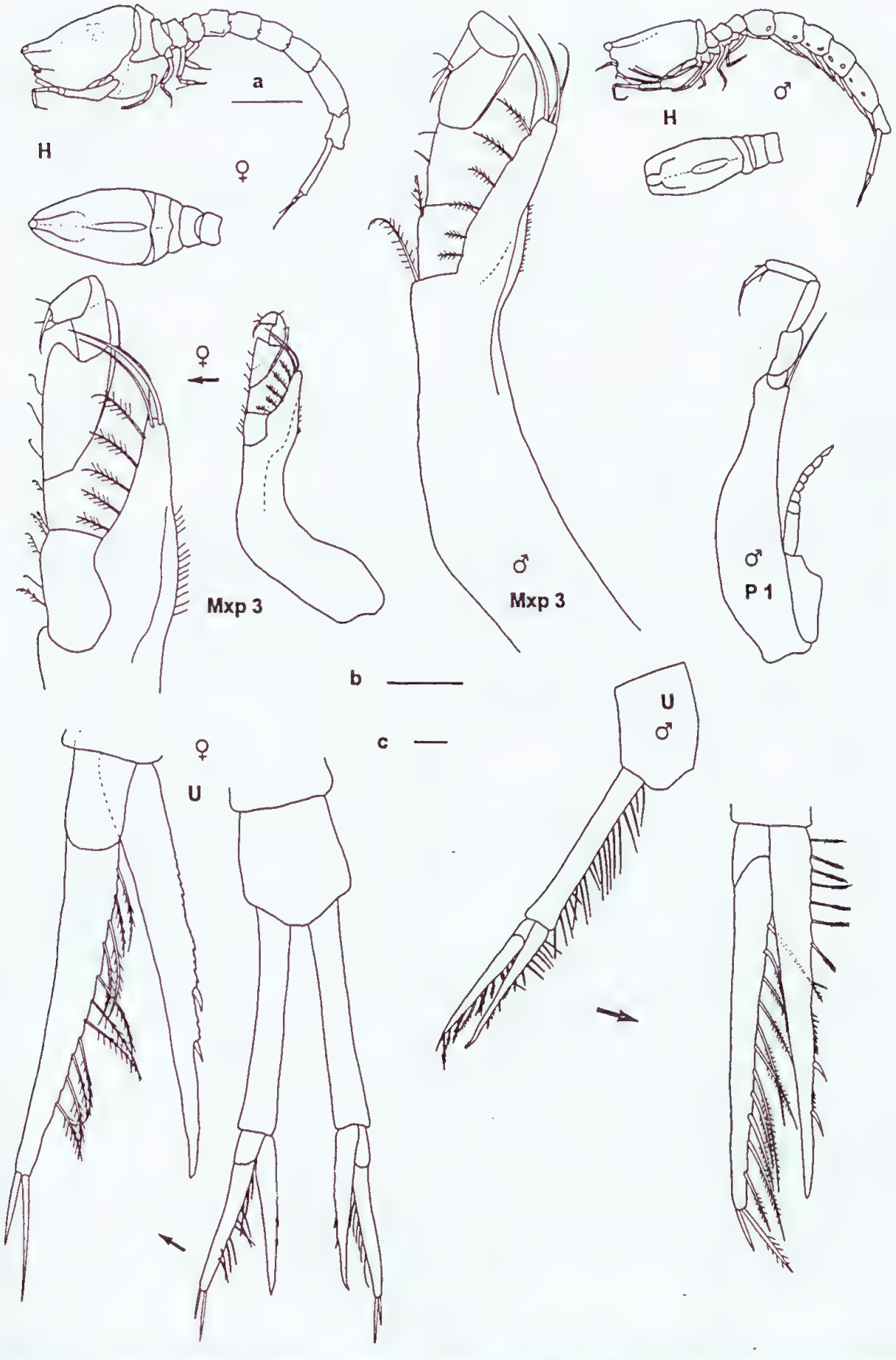

FIGURE 5: *Cyclaspis cottoni*: H: habitus ovigerous female and adult male, Mxp3: maxilliped 3, P1: pereiopod 1, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (Mxp3 male, Mxp3 female enlarged, male and female uropods enlarged), scale c: 0.1 mm (female Mxp3, P1, U).

ovigerous and 3 non-ovigerous females, 1 male (broken), 12 juveniles; SA: 129 (Port Augusta): 10 females, 4 males, 2 juveniles; VIC: 148: 1 ovigerous, 6 non-ovigerous and 7 juvenile females; ZMH K 39918.

Remarks

Hale (1937) described an ovigerous female and some years later (Hale, 1944) the male. The most striking characters are impressions at the termination of the anterior, clear-cut part of the dorsal carina and waviness of the double posterior portion of the carapace (Hale 1937; 1944). Hale stated the close position to *C. herdmani* Calman, 1904. It differs from that species in uropods' exopods distally being truncate with two terminal spines rather than acute as in *C. herdmani*.

The specimens from Tasmania (Figure 5) show the female's uropods' endopods proximal part appearing slightly serrated due to the scaly structure, and having two spines in the distal part, the exopod with 11 plumose setae at inner margin.

The male's endopods' proximal part has eight moderate long setae, the distal part being serrated with two distal spines, acute tip, the exopod with at least 11 plumose setae at inner margin, and the peduncle with 10 long plumose setae at proximal part, and 12 serrated setae at distal part.

Distribution

Extended to Tasmania, South Australia and Victoria.

Cyclaspis granulosa Hale, 1944

Material

Whiting Ground, Waterhouse Bay, east end Thistle Island, 4 March 1931, 8.0–8.3 fathoms; 4 males; SAM C 5989.

Remarks

The specimens from the collection of the South Australia Museum fit quite well the following characters given for *C. granulosa*; namely the roughened structure of the carapace, the shape of pereiopod 1, and the proportions and armature of the uropods.

Cyclaspis pura Hale, 1936

Material

Whalers Bay, Thistle Is., 3 February 1941, submarine light, leg. K. Sheard, 1 large, non-ovigerous, and 2 subadult females; SAM C 5990.

Remarks

The specimens belong to the 'levis group' and resemble closely the description of *C. pura* given in Hale (1936, 1944) in that the uropod's peduncle is only a little longer than the rami, without long setae, and the exopod has two terminal mucrones; the uropod's endopod is acute and in the present material has three marginal serrated spines distally, proximal part serrated; reticulation of carapace as figured in Hale's description.

Cyclaspis supersculpta Zimmer, 1921
(Figure 1)

Material

WA: 46: 4 subadult females, 6 juvenile females, 2 adult males, 15 juveniles; ZMH K 39919.

Remarks

Tafe & Greenwood (1996) described *C. chaunosculpta* (see below) as being very similar to *C. supersculpta* Zimmer, 1921, only differing in having (*C. supersculpta*) or not having (*C. chaunosculpta*) lateral bulges on either side of the median dorsal ridge of the carapace; *C. chaunosculpta* with more strongly developed transverse ridges than in *C. supersculpta*. Because of their variability, structures of the carapace are not reliable characters to separate species, "...since the ornamentation does not correspond uniformly with any other obvious distinguishing characters" (Day, 1978). Nevertheless, the ornamentation of the carapace is often used to separate species of the genus *Cyclaspis* (Tafe & Greenwood, 1996). To find out whether the two species *C. supersculpta* and *C. chaunosculpta* are synonyms, more detailed analyses, such as molecular studies, are necessary.

The present material resembles closely the figure in Zimmer (1921).

Cyclaspis strumosa Hale, 1948
(Figure 6)

Material

QLD: Lizard Island 1992: Turtle Bay (15 Nov., 15 m): 1 juvenile female, 1 adult male, 1 juvenile; Turtle Bay (12 Nov., 15 m): 1 juvenile female, 1 subadult male; sand (7 m): 1 subadult female, 2 juveniles; sand (10 m): 1 juvenile; Pidgin Point: 1 juvenile female; Mermaid Bay: 1 juvenile; ZMH K 39924.

Remarks

There are only two species described for

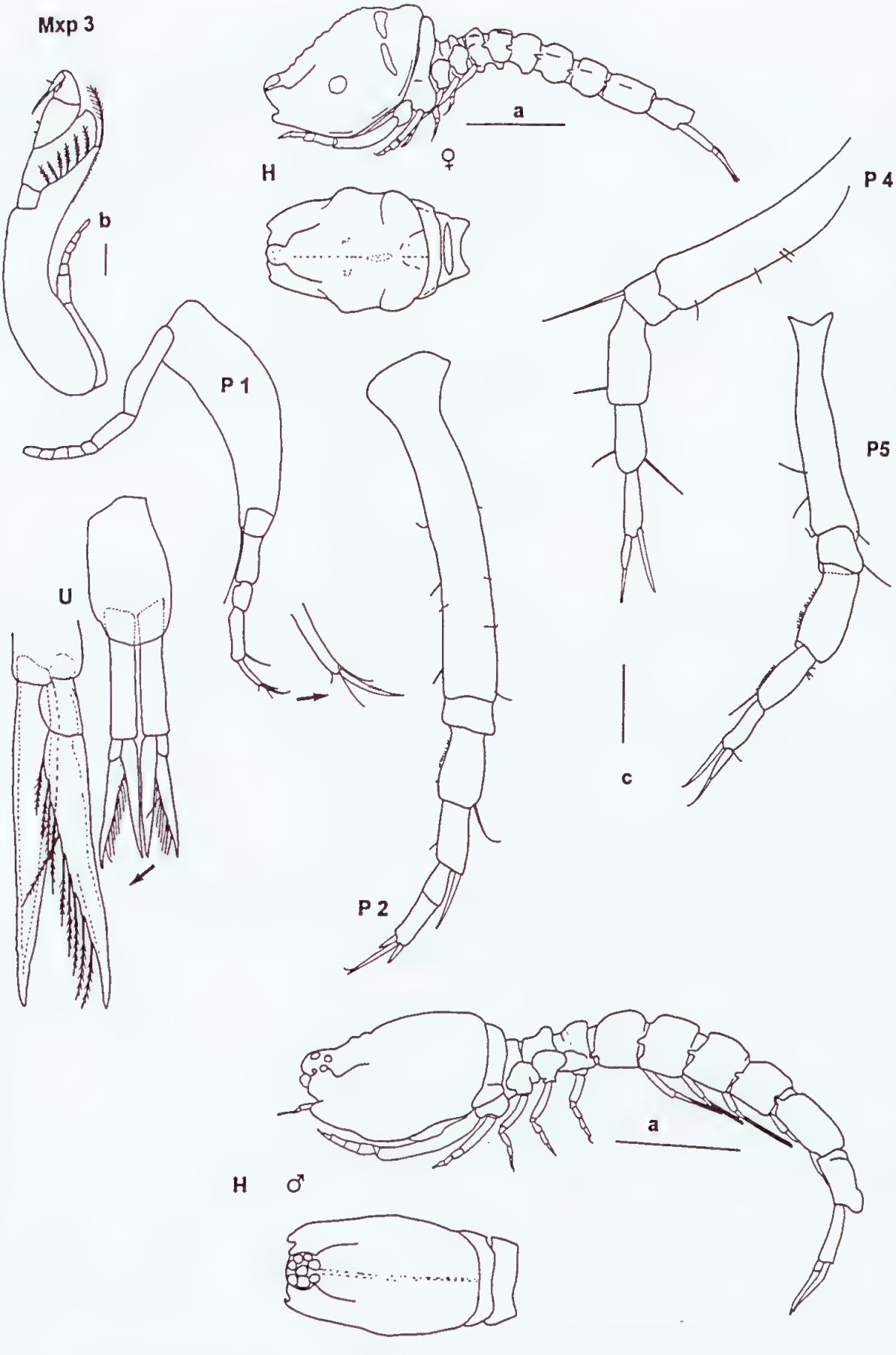

FIGURE 6: *Cyclaspis strumosa*: H: subadult female (above) and male (below) habitus from lateral, and carapace from dorsal; female extremities: Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H, female and male), scale b: 0.1 mm (Mxp 3, P1, U), scale c: 0.1 mm (P2, P4, P5).

Australian waters with an undulated dorsomedian line in the frontal lobes region: *Cyclaspis rudis* Hale, 1948 and *C. strumosa* Hale, 1948. Neither species is included in the determination key presented by Tafe and Greenwood (1996). *C. rudis* is among others characterised by a scaly structure of the carapace's integument. The specimens from Lizard Island resemble in most respects *C. strumosa*. The juvenile female's outline (total length 2.7 mm) from dorsal view with a swollen posterior part of the carapace given in Hale (1948) is different from the outline of the non-ovigerous female (total length 4.75 mm) from Lizard Island. The female's extremities are figured herein. They resemble – aside of the sexual differences typical for males like stouter basis in first pereiopod, and more setae at uropod's peduncle and endopod's inner margin – those of the male given by Hale (1948). The inner and outer margins of pereiopods 1 and 2 are not serrated as in Hale's figures.

Cyclaspis* cf. *strumosa Hale, 1948
(Figure 7)

Material

QLD: Lizard Island 1992: Mermaid Bay (7 m): 2 males; ZMH K 39925.

Description

Based on adult male, 4.3 mm in length.

Carapace 1.3 mm in length; ocular lobe wide, reaching tip of pseudorostral lobes; pseudorostral lobes not meeting in front of ocular lobe; siphonal tube very short; antennal notch narrow, subrostral tooth not acute; mediodorsal line a little undulated; free thoracic segments short, combined 0.7 mm in length, the last two with dorsal hump; abdomen 2 mm in length, longer than carapace and free thoracic segments combined; pleonite 6's proportion length to width 1.7.

First antenna basal article a little geniculated, longer than following two articles combined; accessory flagellum missing, main flagellum two-segmented, its basal article more than twice as long as distal, two terminal aesthetascs; second antenna reaching end of body; mandible with four teeth at pars incisiva, 12 long and strong setae between pars incisiva and pars molaris.

Maxilliped 3 basis longer than rest of extremity, distal prolongation over articulation merus to carpus, ischium longer than body of merus, merus with wide and long distal prolongation reaching articulation carpus to propodus, carpus distally widened, as wide as length of propodus, dactylus short with stout terminal seta, exopod present; pereiopod 1 basis longer than rest of extremity, propodus second longest article, exopod present (not figured); pereiopod 2 basis subequal to rest of extremity, merus subequal in length to carpus, carpus with three outer distal serrated setae, propodus shorter than dactylus, the latter with two short and one distal setae, which is longer than dactylus; pereiopods 3 to 5 similar in shape, basis shorter than rest of extremities, merus to propodus subequal in length, dactylus short, distal seta at propodus at least equal in length to dactylus and its terminal seta combined; uropod's peduncle equal in length to pleonite 6, a little longer than unsegmented endopod (length proportion 1.1), 13 plumose setae at inner margin of peduncle and endopod as well, both rami with acute tip, no terminal seta.

Female unknown.

Remarks

The specimens from Lizard Island resemble the species described by Hale (1948), but differ from the described adult male in basis, merus and carpus of pereiopod 1 and 2, and uropods' endopods having no serration.

Cyclaspis* cf. *agrenosculpta Tafe & Greenwood, 1996
(Figure 8)

Material

QLD: Lizard Island 1992: Turtle Bay (15 m, sand): 1 subadult and 1 juvenile female; Watson's Bay (17 m): 1 female with developed oostegites; ZMH K 39921.

Remarks

Female (subadult, total length 7.62 mm) from Watson's Bay, with right uropod's endopod's subacute tip a little damaged, inner margin serrated with nine hyaline 'teeth'; exopod with 11 plumose setae, subacute tip, rami equal in length, longer than peduncle, length proportion peduncle to rami 0.78, length proportion peduncle to pleonite 6 is 0.81; these specimens from Lizard Island differ from those described by Tafe & Greenwood (1996) in having uropod's rami equal in length instead of exopod longer, and peduncle shorter instead of longer than rami and pleonite 6, respectively, in Moreton Bay specimens. Habitus, shape of first and second pereiopods, sculpturing of carapace and structure of integument are the same in Lizard Island and Moreton Bay females, so they seem to be conspecific. Additional figures

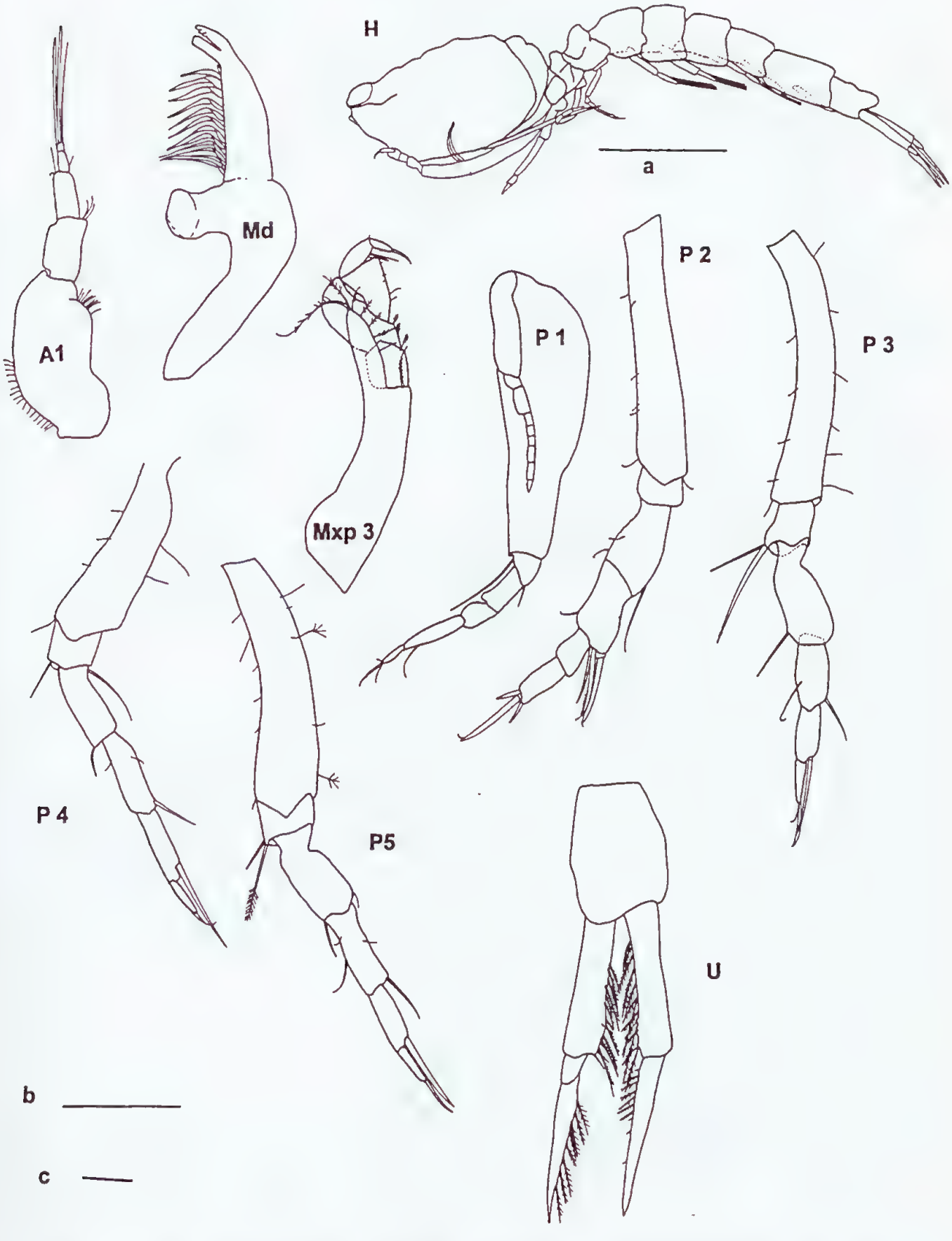

FIGURE 7: *Cyclaspis* cf. *strumosa* male: H: habitus, Md: mandible, A1: first antenna, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods, left exopod and right endopod figured. Scale a: 1 mm (H), scale b: 0.1 mm (A1, Md, P2, P3, P4, P5), scale c: 0.1 mm (Mxp 3, P1, U).

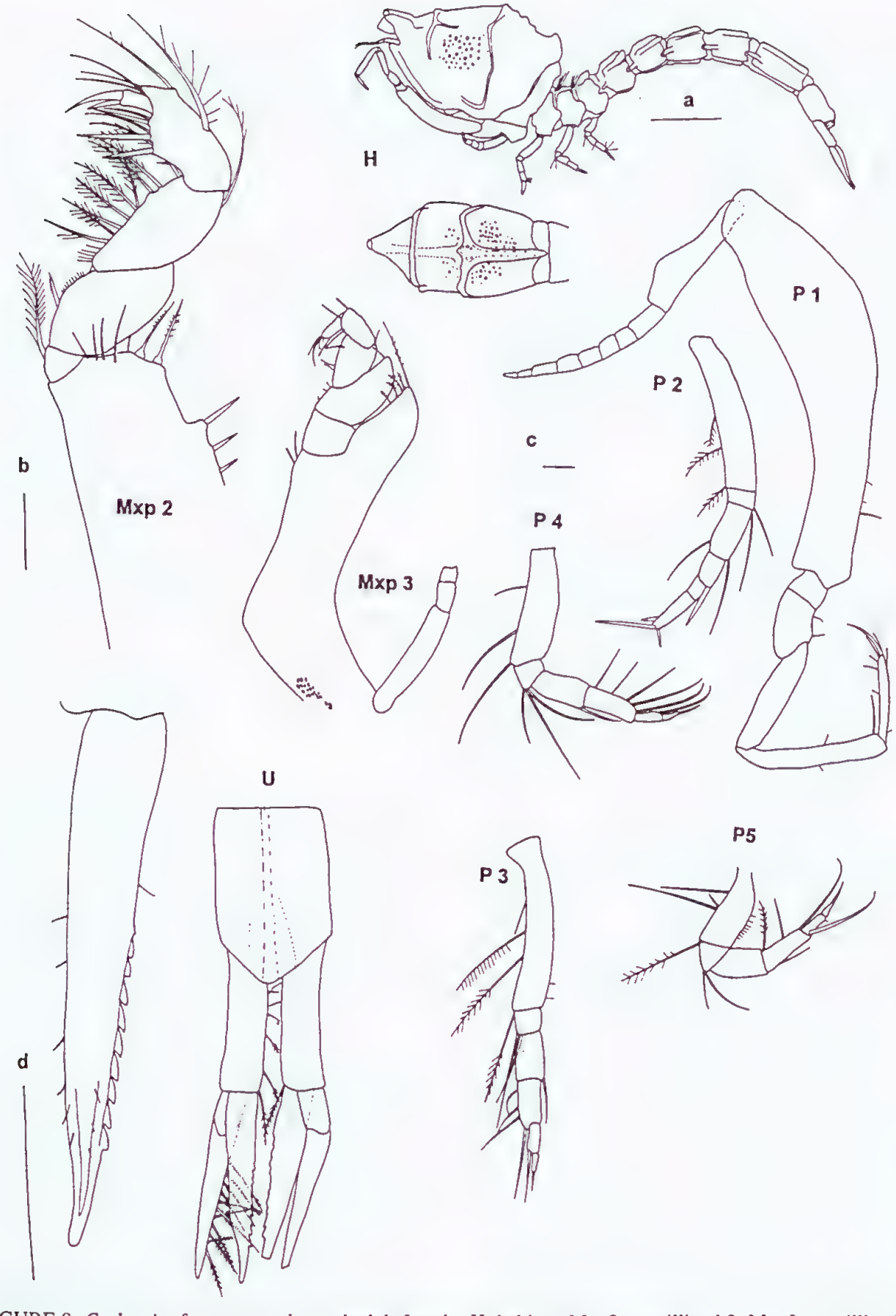

FIGURE 8: *Cyclaspis* cf. *agrenosculpta* subadult female: H: habitus, Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1 = pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (Mxp2), scale c: 0.1 mm (Mxp 3, P1, P2, P3, P4, P5, U), scale d: 0.1 mm (uropod's endopod enlarged).

of maxilliped 2 and 3, and pereiopods 1 to 5 are given herein (Fig. 8).

Cyclaspis lissa sp.n.
(Figures 9 and 10)

Material

1 juvenile male, 12 juveniles; WA-27: 1 subadult female, 1 subadult male, 4 juveniles; WA-28: 2 juvenile specimens; WA-39: 2 subadult males, 1 subadult female, 2 juveniles; WA-66: holotype: 1 ovigerous female, paratypes: 1 ovigerous female, 2 males, additional specimens: 5 ovigerous and 20 subadult females, 2 adult and 6 subadult males, 24 juveniles; WA-67+68: 1 subadult female; ZMH K 39926. WA-10: 4 ovigerous females, 3 subadult and 5 juvenile females; SAM C 6078.

Holotype: female ZMH K 39927, K 39928: extremities of paratypes female and male

Leg.: G. Hartmann & G. Hartmann-Schröder

Date: 21 October 1975

Locus typicus: Western Australia, Drummonds, close to Geraldton, fine sand

Paratypes: 1 female used for dissection, 1 male, 1 male used for dissection.

Diagnosis

Cyclaspis with no ridges, pits or tubercles on the carapace in female, in male no distinct humps near the dorsal end of carapace, no granular structure on the carapace; very short pseudorostral lobes hardly meeting in a point in front of the ocular lobe; basis of pereiopod 1 without distal tooth and longer than the rest of extremities; uropod's peduncle longer than pleonite 6, and longer than exopod; uropod's exopod slightly longer than endopod; uropods' rami ending with acute tips, no terminal setae or mucrones.

Description

Based on holotype, ovigerous female, total length 3.4 mm.

Carapace smooth, dorsomedian carina present, not pronounced; pseudorostrum very short, meeting in a point in front of ocular lobe; siphonal tube short; antennal notch very small, small subrostral tooth acute; integument calcified; ocular lobe present. Four thoracic segments visible from above, first segment visible in ovigerous female only from lateral, free thoracic segments nearly half as long as carapace; abdomen as long as carapace and thoracic segments combined; pleonite 6 is 1.4 times longer than wide, shorter than uropod's peduncle.

Description of extremities based on paratype, ovigerous female.

Maxilliped 2 basis longer than rest of extremity; merus, carpus and propodus of similar length, dactylus shorter, with stout terminal seta; maxilliped 3 with exopod, geniculated basis longest article, with distal process reaching joint merus to carpus, ischium short, merus with distal process reaching joint carpus to propodus, carpus widened, propodus stout, shorter than carpus, with two terminal setae, dactylus short and stout with stout terminal seta, two subterminal setae.

Pereiopod 1 basis slender, longer than rest of extremity, merus a little longer than ischium, carpus and propodus subequal in length, both a little longer than merus, dactylus slender with one terminal and two subterminal slender setae, exopod present; pereiopod 2 basis shorter than rest of extremity, ischium short, merus second longest article, dactylus subequal in length to merus, with one terminal and two subterminal setae; pereiopod 3 basis about as long as rest of extremity, ischium a little shorter than merus, both articles combined a little shorter than carpus, propodus as long as merus, dactylus slender, similar to terminal seta of propodus; pereiopod 4 basis shorter than rest of extremity, carpus second longest article, dactylus half as long as terminal seta, both combined as long as terminal seta of propodus; pereiopod 5 carpus second longest article after basis, dactylus as long as terminal seta of propodus. Uropod's peduncle without spines at inner margin, longer than exopod, unsegmented endopod shorter than exopod; both rami with acute terminal ending; endopod with 6 serrated spines, exopod with 6 setae at inner margin.

Male: Pseudorostral lobes hardly meeting in a point in front of ocular lobe. Male has developed pleopods of same length as holotype; carapace shorter than in female, abdomen longer than carapace and free thoracic segments combined, four pedigerous thoracic segments visible.

Male's extremities differ from female's — extremities are longer and basis of pereiopod 1 stouter. Uropod's peduncle 1.7 times longer than pleonite 6, inner margin with 18 plumose setae, exopod longer than endopod, the latter with 11 short and proximally with two long setae.

Etymology

The new species is named after the smooth structure of the carapace.

Remarks

Many species of the genus *Cyclaspis* have no

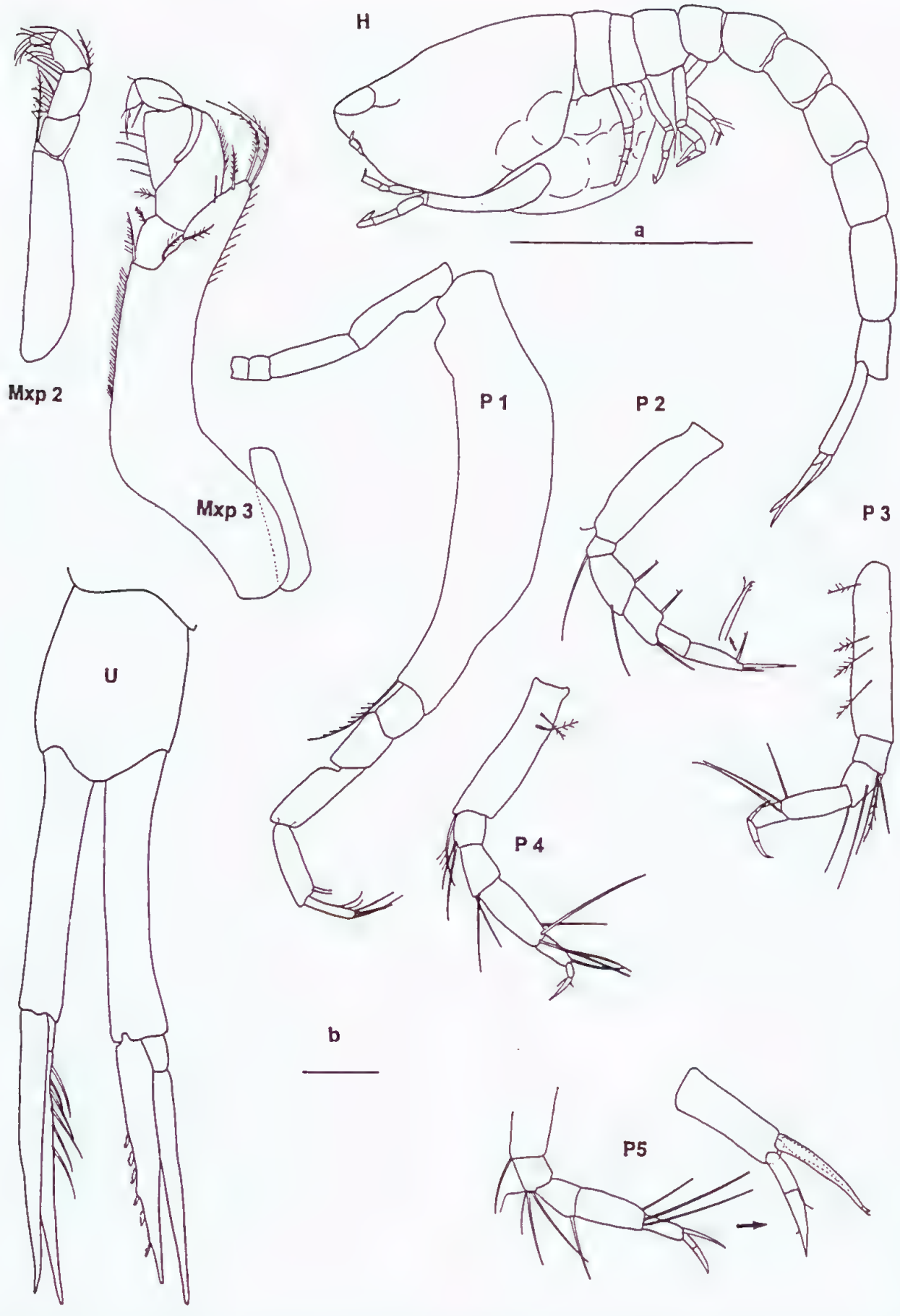

FIGURE 9: *Cyclaspis lissa* sp.n. ovigerous female: Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (Mxp2, Mxp3, P1, P2, P3, P4, P5, U).

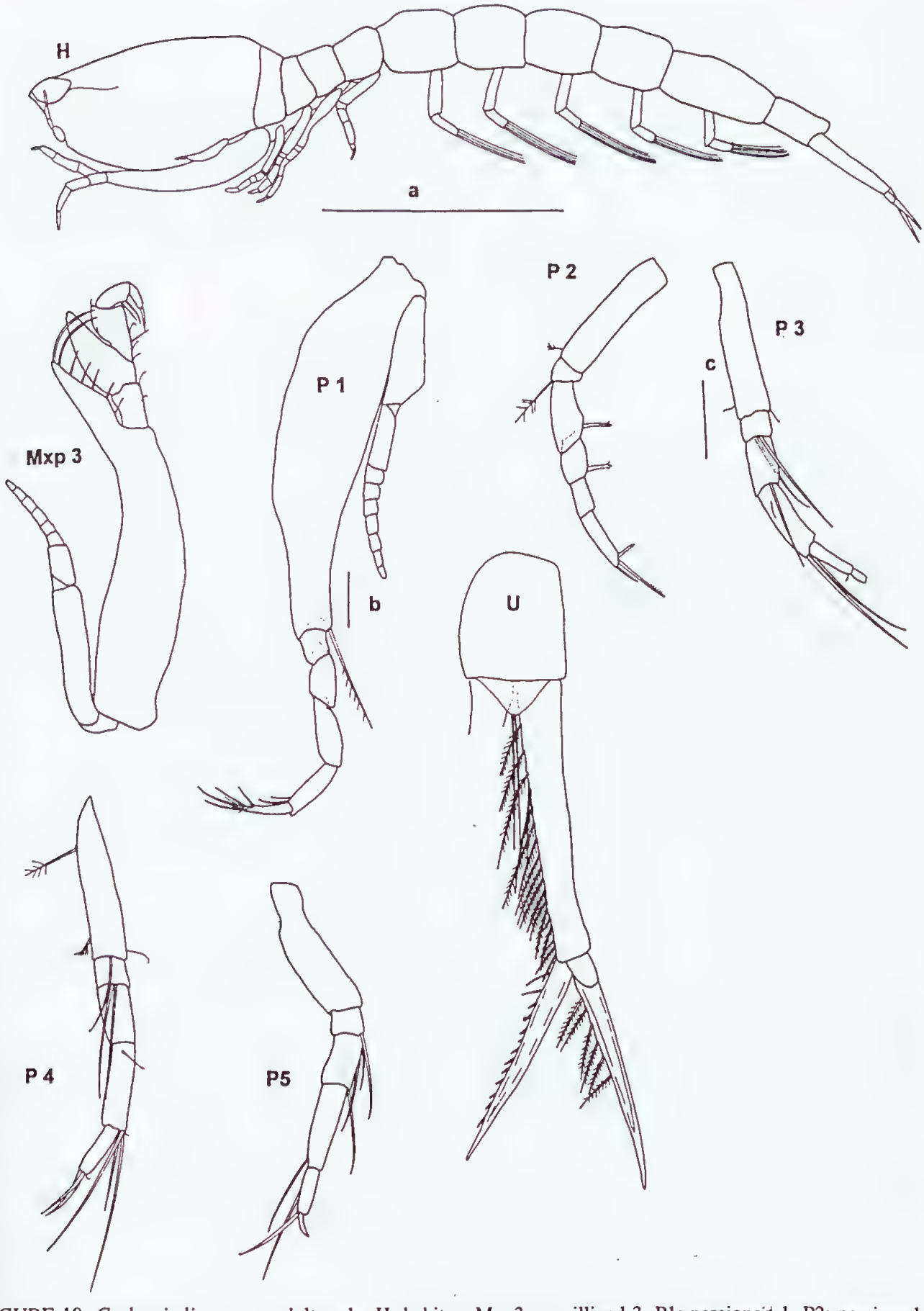

FIGURE 10: *Cyclaspis lissa* sp.n. adult male: H: habitus, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods (the two long 'setae' between the uropods peduncles belong to the antenna's flagella). Scale a: 1 mm (H), scale b: 0.1 mm (Mxp3, P1, U), scale c: 0.1 mm (P2, P3, P4, P5).

ridges, pits or tubercles on the carapace, Hale (1944) erected a key to these species in his section 1. In this section he separated the 'picta group' with eyes developed and the pseudorostral lobes meeting for an appreciable distance in front of the ocular lobe, and the 'levis group' with pseudorostral lobes barely or not meeting in front of the ocular lobe. Tafe & Greenwood (1996) followed him in their emended key. Thirty-five *Cyclaspis* species with a smooth carapace are currently known. Only two species out of these have the following character combination as in the species described above:

1) uropods' rami ending with acute tips, no setae or mucrones
2) very short pseudorostrum or pseudorostral lobes hardly meeting in front of ocular lobe
3) uropod's peduncle longer than pleonite 6
4) uropod's peduncle longer than exopod
5) uropod's exopod longer than endopod
6) basis of pereiopod 1 without distal tooth and longer than the rest of extremities.

The combination of these characters is given in *Cyclaspis sheardi* Hale, 1944. The new species is close to *C. sheardi* because of the terminal seta of pereiopod 2 being longer than dactylus in both species. It differs from *C. sheardi* in not having distinct humps near the dorsal end of carapace in males, and in the absence of a granular structure on the carapace. The pseudorostral lobes in males in *C. sheardi* are very short but clearly meet in front of carapace, whereas they hardly do in *C. lissa* sp.n.

Cyclaspis ursulae sp.n.
(Figures 11 and 12)

Material

WA: 23: 2 subadult females, 1 adult and 1 subadult male, 8 juveniles; WA-30: 28 juveniles; WA-37: 1 ovigerous and 1 subadult female, 1 adult and 7 subadult males, 17 juveniles; ZMH K 39923. WA- 4+15: 2 subadult females, 1 subadult male, 4 juveniles; SAM C 6079.

Habitus: ovigerous female holotype, subadult and adult male

Extremities: WA-23 adult male total length 5.4 mm, pleon damaged; WA-14+15 female with developing oostegites, only carapace to first pleonite, carapace length 1.6 mm.

Holotype: ovigerous female ZMH K 39922a, ZMH K 39922b: extremities of paratypes

Leg.: G. Hartmann & G. Hartmann-Schröder

Date: 2 October 1975

Locus typicus: 7 km east of Dampier, Horsines Cove

Diagnosis

Cyclaspis with quadrilateral area on each side of the carapace defined by ridges, the anterior transversal ridge not crossing the frontal lobe of the carapace of the female, pitted carapace structure in female, unsegmented uropod's endopod acute, uropod's exopod with two distal spines.

Description

Based on the holotype, 5.6 mm length in total.

Carapace seen from lateral with two transverse ridges, the anterior not crossing the frontal lobe, but turning backwards to meet the two 'horns' reaching forwards, formed by posterior ridge; seen from dorsal transverse ridges do not cross dorsomedian ridge but run parallel to it in posterior part; pseudorostral lobes do not meet in front of elongated ocular lobe; siphonal tube short; dorsomedian line a little pronounced; antennal notch small, anterolateral margin smooth, anteroventral margin of carapace smooth, integument reticulate, well calcified; eyes present; four free thoracic segments visible, the first of them (second pedigerous segment) with dorsal prolongation, carapace and free thoracic segments combined 2.81 mm in length.

Abdomen about same length as carapace and free thoracic segments combined, with lateral articular processes and dorsally a faint ridge reaching the fifth pleonite; pleonite 6 shorter than peduncle of uropod, length proportion of peduncle to pleonite 6 is 1.38.

Description of extremities based on paratype (WA-14+15) subadult female, carapace and free thoracic segments combined 2.53 mm in length, abdomen missing.

First antenna basis only a little geniculated, longer than two following articles, outer margin hairy, distal article second longest; main flagellum two-segmented with four aesthetascs and two short setae, accessory flagellum short, less than half as long as main flagellum's basal article, with two short setae. Maxilliped 2 basis longer than rest of extremity, distal inner part with one strong spine, merus distal inner part with one long plumose seta reaching distal end of carpus; this article second longest, at inner margin four strong plumose setae; propodus with four pairs of plumose (only one row figured) setae at inner margin, dactylus short with strong terminal spine; maxilliped 3 basis a little geniculated, distal outer

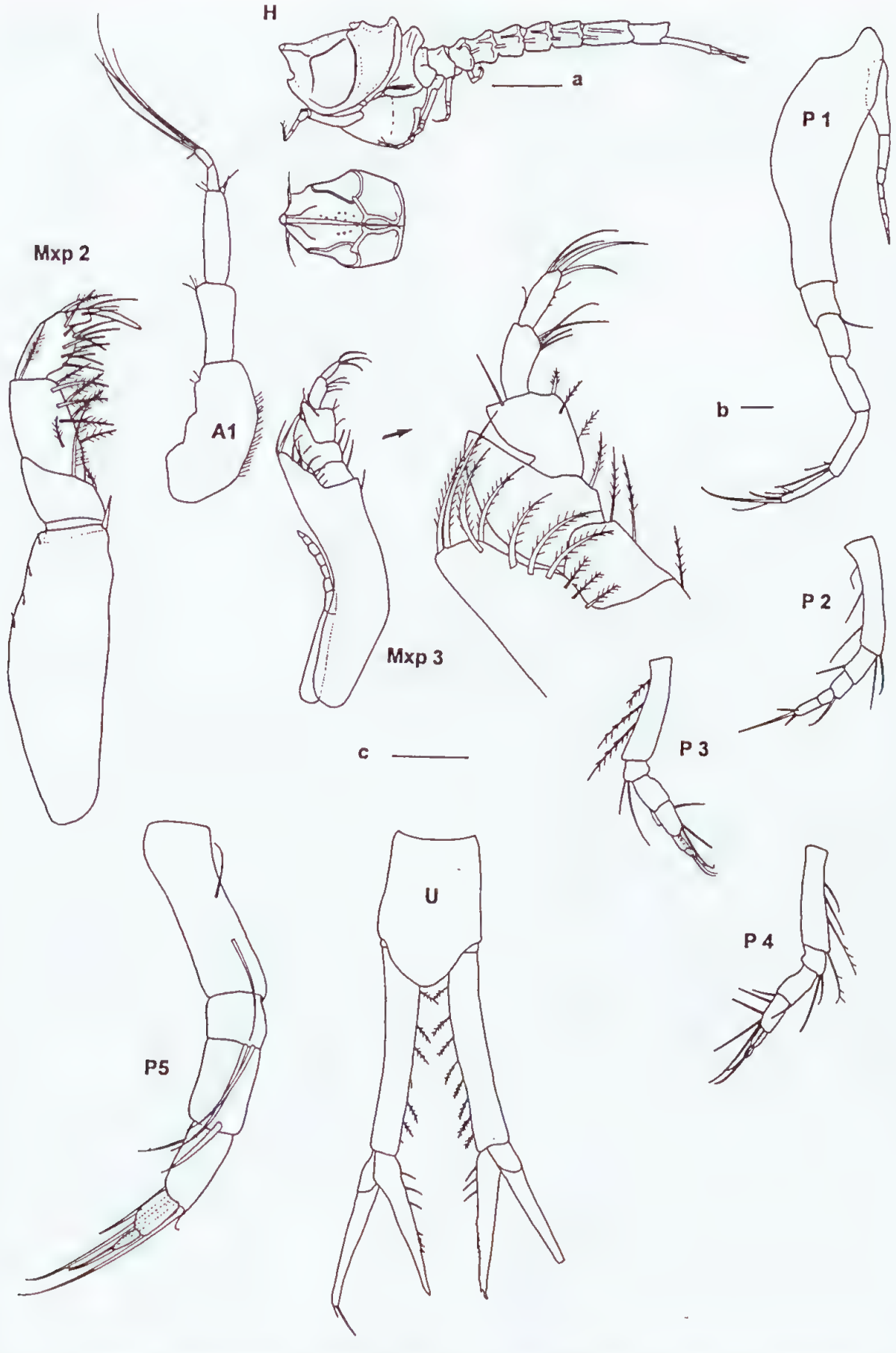

FIGURE 11: *Cyclaspis ursulae* sp.n. ovigerous female: H: habitus, subadult female A1: antenna 1, Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (Mxp3, P1, P2, P3, P4, U), scale c: 0.1 mm (A1, Mxp 2, Mxp 3 distal part, P5).

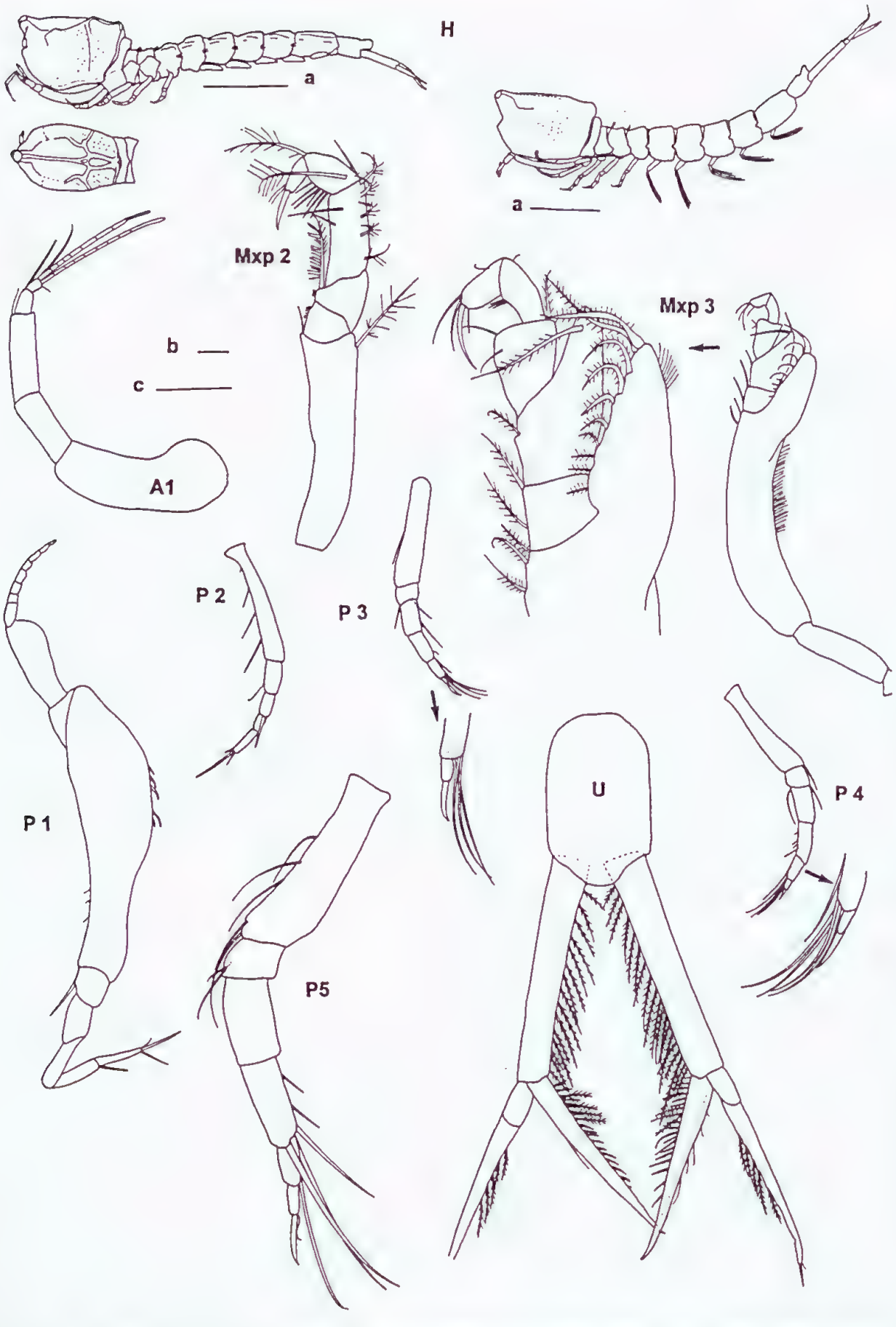

FIGURE 12: *Cyclaspis ursulae* sp.n. male: H: habitus subadult (left) and adult (right) male, subadult male A1: antenna 1, Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (Mxp3, P1, P2, P3, P4, U), scale c: 0.1 mm (A1, Mxp 2, Mxp 3 distal part, P5).

prolongation reaching distal third of merus, prolongation with ten plumose setae; merus outer distal prolongation reaching articulation carpus to propodus; carpus second longest article with strong simple spine at outer and plumose seta at inner distal margin, propodus a little longer than dactylus, dactylus with four terminal spines, one of them strong; exopod present.

Pereiopod 1 basis subequal in length to distal articles combined, ischium equal in length to merus, propodus second longest article, slender dactylus a little shorter than carpus, with three terminal setae, one of them stronger; exopod present. Pereiopod 2 basis longer than rest of extremity, ischium missing, merus second longest article, carpus with one strong distal seta, dactylus longer than carpus, with one strong terminal seta more than twice as long as dactylus, and two subterminal setae.

Pereiopod 3 basis shorter than rest of extremity, ischium with two distal setae, one of them reaching beyond articulation carpus to propodus, merus and carpus equal in length, carpus with two distal setae, two of them reaching to tip of dactylus' strong terminal seta. Pereiopod 4 similar to pereiopod 3. Pereiopod 5 basis shorter than rest of extremity, ischium with two long distal setae, merus with one strong distal spine, carpus with three distal setae, two of them reaching further than dactylus' strong terminal seta.

Uropod's peduncle longer than pleonite 6, and 1.4 times longer than endopod, inner margin with seven or eight simple setae, endopod with three setae at proximal part of inner margin, distal part serrated and with five or seven spines, tip subacute; exopod longer than endopod, inner margin appearing serrated due to scaly structure, one long and one shorter terminal seta.

Adult (5.1 mm in length) and subadult (4.6 mm in length) males (WA-37).

Carapace smooth in adult, sculptured in female as in subadult male, pleonite 6 shorter than uropod's peduncle.

Description of extremities based on male paratype (WA-23). First antenna as in female but first article of peduncle longer and more slender, accessory flagellum minute with three aesthetascs.

Maxilliped 2 as in female, basis with one, propodus with additional two strong plumose setae, carpus with plumose setae at outer margin; maxilliped 3 as in female; pereiopod 1 as in female, basis with 5 spines; pereiopod 2 as in female, basis longer and more slender; pereiopods 3 to 5 as in female; uropods, aside from sexual differences (numerous setae at inner margins of peduncle and rami), as in female.

Etymology

The species is named in memory of Ursula Heuer, the co-collector of the material from Indonesia.

Remarks

The new species and the three species mentioned before belong to the *exsculpta*-group of section 2 (Hale, 1944; Tafe & Greenwood, 1996). This group contains 18 species with a quadrilateral area on each side of the carapace defined by ridges or tubercles, distinct and depressed in females, often indistinct in males (Tafe & Greenwood, 1996). This group can be extended by two species, *C. strumosa* and *C. rudis*. From these species only males or young females are known; the females might show the typical transverse folds while the males have carapace structures like males of other species of the *exsculpta*-group. Within the *exsculpta*-group there is a species subgroup with very similar characters: *C. chaunosculpta* Tafe & Greenwood, 1996, *C. persculpta* Calman, 1905, *C. supersculpta* Zimmer, 1921, *C. tribulis* Hale, 1928, *C. exsculpta* Sars, 1887, *C. usitata* Hale, 1932, and *C. alveosculpta* Tafe & Greenwood, 1996.

A comparison of characters of selected species within the *exsculpta*-group is given in Table 2, not including species with big lateral horns as in *C. aspera* Hale, 1944 and *C. bovis* Hale, 1928, and species with aberrant ridges at carapace like *C. australis* Sars, 1887, *C. indoaustralica* Bacescu, 1992 and *C. similis* Calman, 1907.

The new species resembles *C. ornosculpta* Tafe & Greenwood, 1996 from Moreton Bay, Queensland. The main character differing between the two species is the anterior transverse ridge not crossing the frontal lobe of the carapace of the female in *C. ursulae* sp.n.

Genus *Mossambicuma* Day, 1978

Mossambicuma victoriae sp.n.

(Figures 13 and 14)

Material

VIC: 165: 2 females, 2 males, 1 exuvia; ZMH K 39934. 1 male; SAM C 6080.

Holotype: ovigerous female; ZMH K 39932, ZMH K 39933: extremities of paratypes

TABLE 2: Character comparison of the *exsculpta*-group of the genus *Cyclaspis*. C: carpus, M: merus.

***Exsculpta*-group**	***C. agrenosculpta***	***C. alveosculpta***	***C. candida***	***C. chaunosculpta***	***C. ursulae* n.sp female and subad. male**	***C. ursulae* n.sp adult male**
uropod's endopod	bluntly pointed	acute	acute	acute	acute	acute
uropod's exopod	acute	acute or tiny mucro	acute	acute	spine	2 spines
longest ramus	exopod	equal	exopod	equal	exopod	exopod
Length proportion						
peduncle:pleonite 6, male	1.3	0.9	1.2	0.8	1.3	1.4
peduncle:pleonite 6, female	1.0	0.7	–	–	1.4	–
peduncle:endopod, male	1.1	0.8	about 1	0.8	1.2	1.2
peduncle:endopod, female	1.1	0.7	–	–	1.4	–
setae at endopod, male	11 short, 21 long plumose	13 spines, 27 long	plumose setae	9 spines, 12 plumose	4 long, 15 short	4 long, 17 serrated
setae at endopod, female	1 stout, 7 short	11 short	–	–	3 long, 7 spines	–
pereiopod 1	C longer M	C longer M	–	C longer M	C longer M	C longer M
no. of spines at basis, male	18	27	0?	21	–	5
long setae at pereionites	3 to 5	no	3 to 5	3 and 4	3 and 4	3 to 5
structure of carapace	reticulate	reticulate	?	pitted, sponge like	pitted	reticulate
Carapace ridges						
transverse in female	2	2	–	2, first not pronounced	2, not meeting on frontal lobe	2 lateral, 1 from dorsal
transverse in male	2	–	2?	–	–	no
longitudinal	–	humps in female	–	one hump in both sexes	–	1 pair
dorsomedian carina	present	present	–	present	present	present

***Exsculpta*-group**	***C. supersculpta* WA 46**	***C. supersculpta***	***C. exsculpta***	***C. mawsonae***	***C. tribulis***	***C. usitata***
uropod's endopod	acute	acute	acute	acute	acute	acute
uropod's exopod	acute	acute	mucro	acute	acute	acute
longest ramus	subequal	equal	equal	exopod	equal	equal
Length proportion						
peduncle:pleonite 6, male	1	–	0.6	1.2	–	–
peduncle:pleonite 6, female	0.8	0.4	–	–	1	0.8
peduncle:endopod, male	0.9	–	0.6	1.1	–	–
peduncle:endopod, female	0.8	0.6	–	–	1	0.9
setae at endopod, male	7 spines, 7 teeth, 28 plumose	–	4 short, 13 long	7 short, 22 long plumose	–	–
setae at endopod, female	5–6 hairy setae	serrated margin	–	–	14 short spines?	7 short spines
pereiopod 1	C longer M	C equal to M	C longer M	C longer M	C longer M	C longer M
no. of spines at basis, male	15	?	0	0	0	0
long setae at pereionites	3 and 4	3 and 4	3 and 4	3.00	no	no
structure of carapace	–	reticulate	reticulate	reticulate	reticulate	reticulate
Carapace ridges						
transverse in female	–	2	–	–	2	2
transverse in male	–	–	2	1?	–	–
longitudinal	–	–	2 pairs	1 pair	1 pair	–
dorsomedian carina	–	present	present	present	present	present

TABLE 2: (continued)

Exsculpta-group	*C. elegans*	*C. ornosculpta*	*C. prolifica*	*C. persculpta*	*C. rudis*	*C. strumosa*
uropod's endopod	acute	acute	acute	acute	acute	acute
uropod's exopod	spine	with spine	?	acute	acute	acute
longest ramus	subequal	exopod	exopod?	equal	equal	endopod
Length proportion						
peduncle:pleonite 6, male	1.0	1.1	–	–	1	1.1
peduncle:pleonite 6, female	0.8	1.1	–	0.8	–	–
peduncle:endopod, male	1.1	1.3	–	–	0.67	0.9
peduncle:endopod, female	0.9	1.4	1.0	0.8	–	–
setae at endopod, male	18 plumose	7 spines, 12 plumose	?	–	4 setae, 12 long setae	2 stout, 10 slender, serrated
setae at endopod, female	serrated, 5 plumose setae	2 plumose, serrated margin	4 short, serrated	3 spines, serrated	–	–
pereiopod 1	C longer M	C longer M	C longer M	?	C longer M	C shorter M
no. of spines at basis, male	0	0	?	?	0	0
long setae at pereionites	no	no	no	3 and 4	2	no
structure of carapace	?	reticulate	reticulate	pitted	scaly	pitted
Carapace ridges						
transverse in female	2	2	2	2	–	–
transverse in male	2	–	?	–	no	slightly 2 pairs
longitudinal dorsomedian carina	2 pairs present	1 lateral pair present, pronounced	– pronounced	2 pairs present	1 pair present	no present
Remarks	–	–	–	2 horns at middle	–	–

Leg.: G. Hartmann & G. Hartmann-Schröder
Date: 18. January 1976

Locus typicus: Australia, Victoria, southern dead end of Clarence River, near Yamba, brackish water and mangroves

Paratypes: female and male for dissection of extremities.

Diagnosis

Mossambicuma with long siphonal tubes separated but close together; no abrupt border between carapace and second pereionite in female; uropods' peduncles shorter than pleonite 6 and rami; third maxilliped basis and merus with long distal prolongations; basis of pereiopod 1 geniculated; pereiopod 2 distal seta longer than dactylus.

Compared to the other species of this genus, in *M. elongatum* the basis of third maxilliped is shorter and more geniculated, both basis and merus of third maxilliped having a longer distal prolongation in the new species.

Description

Based on the holotype, an ovigerous female, length 2.7 mm.

Carapace compressed, longer than free thoracic segments, first segment fused, lateral ridge running from below frontal lobe dorsoposterior to dorsomedian line; pseudorostrum long, siphonal tubes long, separated but close together. Dorsomedian line pronounced in anterior half, less pronounced in posterior part where lateral ridge runs parallel to dorsomedian line, very last part of carapace without ridge or pronounced dorsomedian line; antennal notch shallow; anterolateral margin smooth; anteroventral margin of carapace smooth; integument weakly pitted; eyes present.

Four thoracic segments visible; abdomen 1.1 times longer than carapace and thoracic segments combined; pleonite 6 is 1.5 times longer than uropods' peduncles and 1.4 times longer than wide.

Description of extremities, based on paratype, ovigerous female, length 3 mm. First antenna long, mid article 1.1 times longer than basal one, both combined 1.1 times longer than distal one; main flagellum two-segmented, terminal with one aesthetasc and one short, two long setae, accessory flagellum reduced, replaced by one seta; maxilliped 3 basis geniculated, with long and

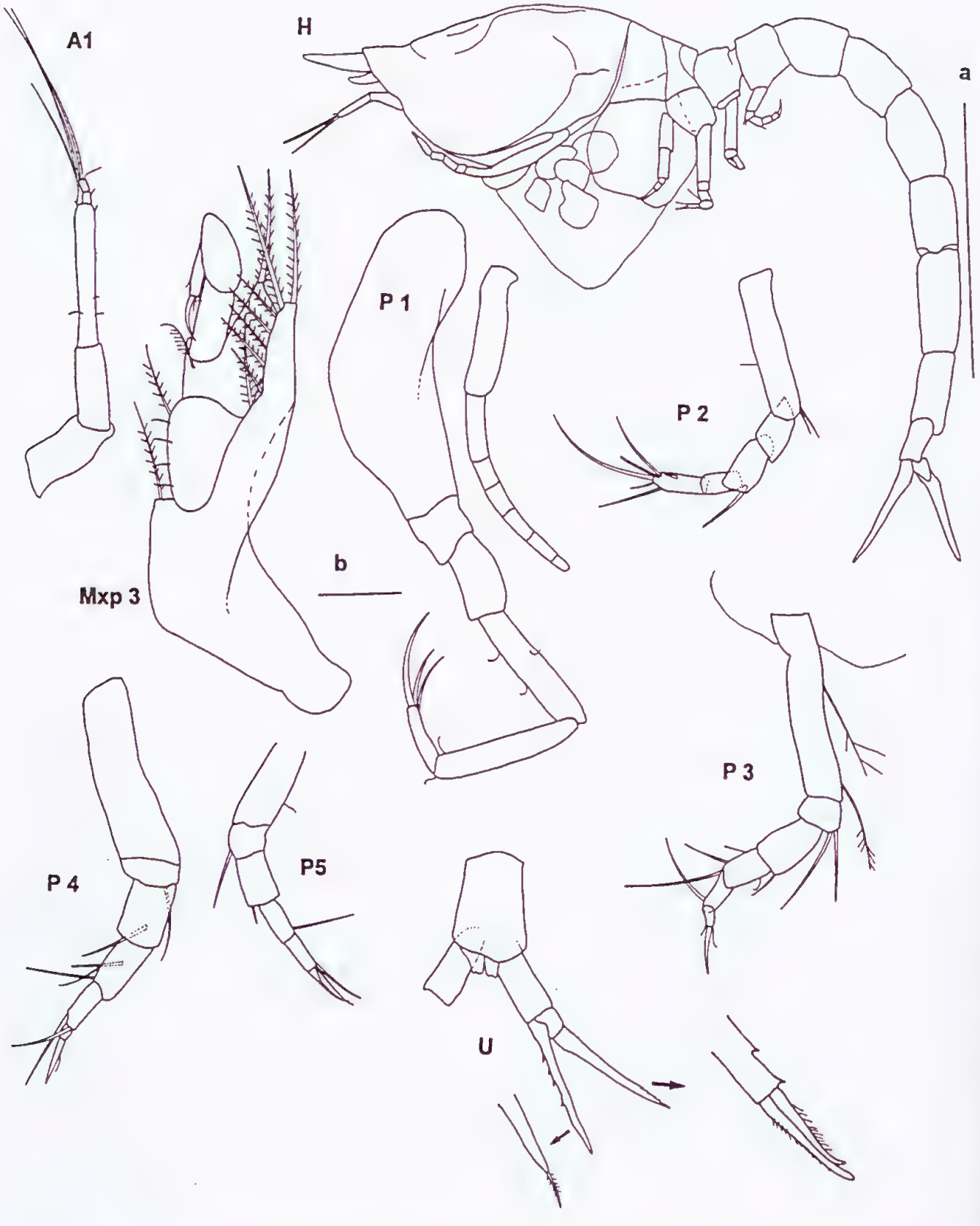

FIGURE 13: *Mossambicuma victoriae* sp.n. ovigerous female: H: habitus, A1: first antenna, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (A1, Mxp3, P1, P2, P3, P4, P5, U).

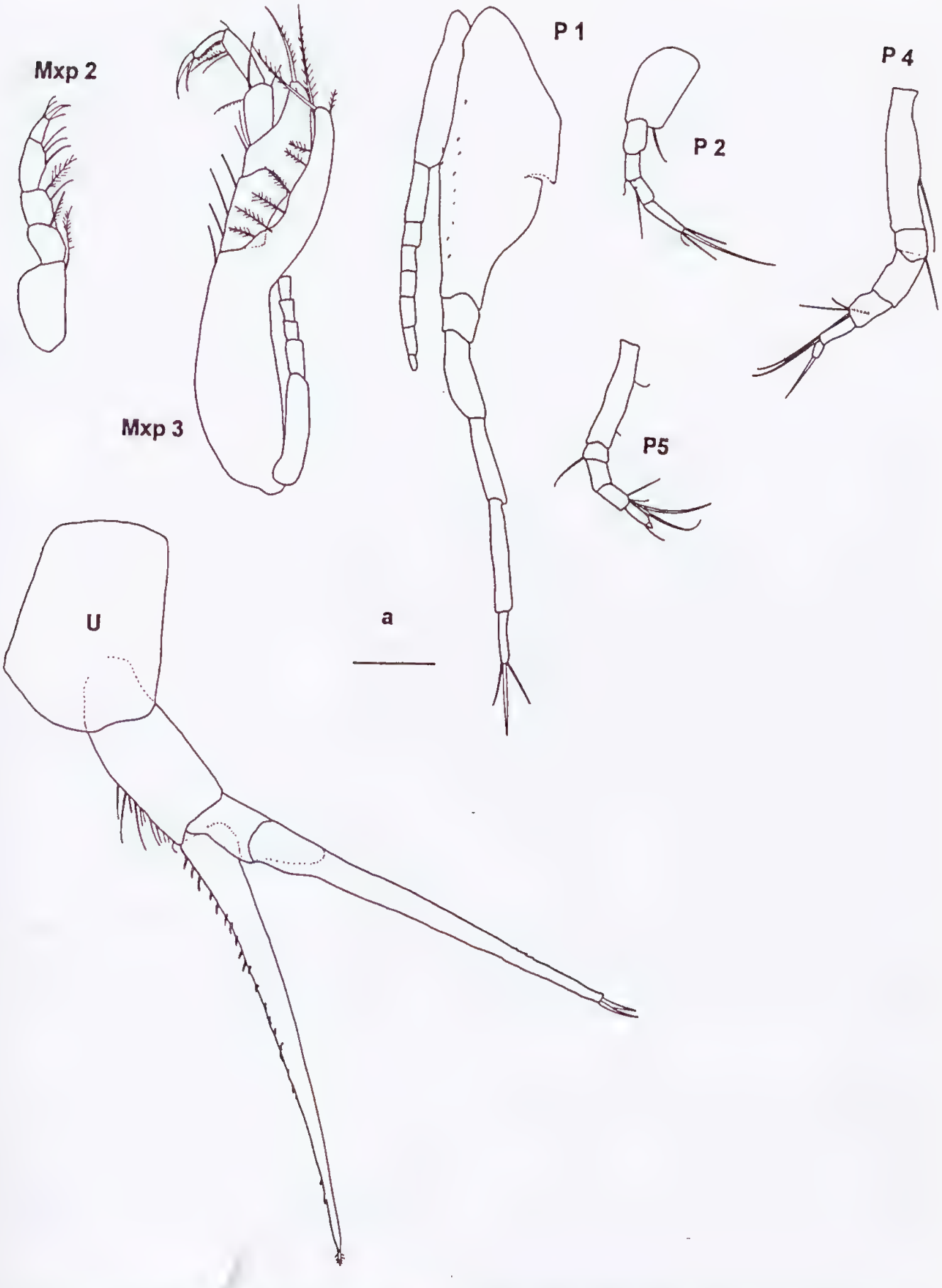

FIGURE 14: *Mossambicuma victoriae* sp.n. male: Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 0.1 mm (Mxp2, Mxp3, P1, P2, P4, P5, U).

wide outer distal prolongation carrying eight plumose setae at inner margin, the two distal ones very long, prolongation almost reaching articulation carpus to propodus; ischium longer than merus, the latter with long and wide outer distal prolongation reaching articulation carpus to propodus, propodus egg shaped, dactylus slender with terminal claw-like seta, exopod present (not figured); pereiopod 1 basis shorter than rest of extremity, slightly geniculated, ischium shorter than merus, both articles combined shorter than carpus, propodus second longest article, dactylus with three terminal setae, exopod present; pereiopod 2 basis shorter than rest of extremity, ischium missing, merus equal in length to dactylus, longer than propodus but shorter than carpus, terminal seta longer than dactylus; pereiopod 3 basis equal in length to rest of extremity, distal seta of carpus reaching tip of terminal seta which is longer than dactylus; pereiopod 4 basis equal in length to rest of extremity, distal seta longer than dactylus; pereiopod 5 similar in shape to pereiopod 4; uropod's peduncle short compared with pleonite 6 and rami, exopod two-segmented, longer than endopod; dorsal ridge with double row of scales, distal tip with two serrated spines; endopod unsegmented with four strong and short spines at inner margin; outer margin scaly, terminal tip with acute plumose seta.

Males dorsomedian line and lateral ridge less pronounced than in female; extremities dissected from male paratype, length 2.5 mm; second antenna reaching articulation of pleomers 3 to 4, pereiopod 1 basis more stout but rest of extremity more slender, pereiopod 2 shorter than in female, uropods' peduncles with 11 setae at distal part of inner margins, endopod with 20 spines at proximal part, distal part with scales, one terminal plumose seta as in female, exopod with two serrated terminal spines.

Etymology

The new species is named after the type locality.

Remarks

Day (1978) described a new genus, *Mossambicuma*, with the striking characters: ischium of maxilliped 3 larger than merus, basis of pereiopod 1 without distal projection, second pereiopod without ischium, uropods' peduncles shorter than pleonite 6 and rami, pleonite 6 shorter than fifth abdominal somite. She mentioned the resemblance to the genus *Eocuma* Marcusen, 1894 but she also stressed the differences from this genus, such as the form of the carapace and the first pereiopod not having the distal projection of basis typical for *Eocuma*. The genus *Mossambicuma* seemed to be monotypic, with the type species *M. elongatum* Day, 1978 found only at the type locality, the Morrumbene estuary (Mühlenhardt-Siegel, 1996). The Australian new species clearly belongs to this genus. It differs from the known species in the female's habitus as there is no abrupt border between carapace and second pereionite, the siphonal tubes are longer, the basis of third maxilliped is shorter and more geniculated, both basis and merus of the third maxilliped have a longer distal prolongation, the basis of pereiopod 1 is geniculated, pereiopod 2 has a distal seta that is longer than the dactylus in the new species but shorter in *M. elongatum*.

Subfamily VAUNTHOMPSONIINAE Sars, 1878

Genus ***Glyphocuma*** Hale, 1944

Glyphocuma oculodentata sp.n.
(Figure 15)

Material

QLD: Lizard Island 1992: Turtle Bay (15 November, 15 m): 3 subadult females; sand (10 m): 1 subadult female, 2 juveniles; Mermaid Bay (7 m): 1 juvenile; Lagoon (7 m): 1 juvenile; ZMH K 39936.

Holotype: adult but non-ovigerous female; SAM C 5997a, SAM C 5997b: extremities of paratype

Leg.: V. Siegel, U. Mühlenhardt-Siegel

Date: 20 November 1992

Locus typicus: Australia, Queensland, Lizard Island, Watson's Bay, 16 m

Paratypes: Watson's Bay (16 m): 2 adult females, 3 juvenile females; SAM C 5998.

Diagnosis

Glyphocuma with six dorsomedian teeth in anterior half of carapace and one strong tooth at anterior end of ocular lobe reaching the tip of pseudorostrum, accessory flagellum of antenna 1 half as long as basal article of main flagellum, uropod's endopod distal article a little longer than basal.

Description

Based on holotype, a subadult female, 7.6 mm in length.

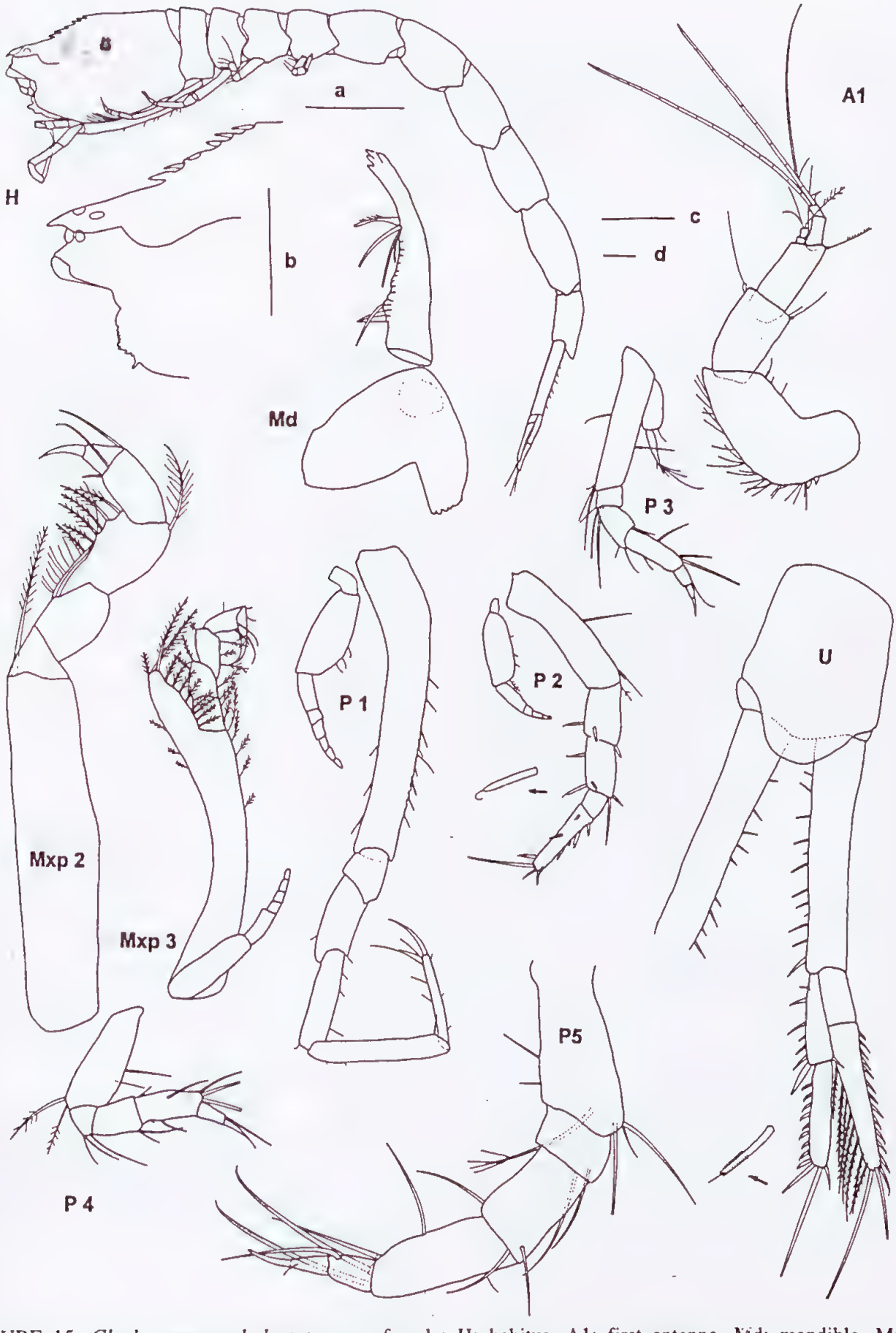

FIGURE 15: *Glyphocuma oculodentata* sp.n. female: H: habitus, A1: first antenna, Md: mandible, Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropod. Scale a: 1 mm (H), scale b: 0.5 mm (anterior part of carapace enlarged), scale c: 0.1 mm (A1, Md, Mxp2, P5), scale d: 0.1 mm (Mxp3, P1, P2, P3, P4, U).

Carapace slender, as long as free thoracic segments, straight to posterior part of frontal lobe, the dentated line ascending, the undentated posterior half straight; pseudorostrum and siphonal tube short; dorsomedian line dentated in anterior half with six teeth; antennal notch reaching the posterior end of ocular lobe; subrostral tooth not pronounced; anterolateral margin serrated; anteroventral margin of carapace smooth; integument with fine reticulate structure as figured in Figure 17; eyes present.

Five free thoracic segments visible from above, the first one short, laterally covered by carapace and second free thoracic segment, third and fourth segments laterally produced backwards; abdomen longer than carapace and thoracic segments combined; pleonite 6 shorter than uropod's peduncle.

The description of the extremities is based on paratype, a female. First antenna basal article geniculated with many hair-like setae, both following articles equal in length, main flagellum two-segmented, distally with two aesthetascs and one annulated long seta, accessory flagellum two-segmented, half as long as basal article of main flagellum, with three terminally plumose setae and one shorter simple seta. Mandible with 17 setae, pars incisiva with four terminal 'teeth', pars molaris short and stout. Maxilliped 2 straight, basis longer than rest of extremity, ischium more than half as long as merus, carpus second longest article with 6 plumose setae at inner margin and one at distal outer margin, dactylus short and stout, ending with stout terminal seta; maxilliped 3 basis long and slender, distal prolongation with 11 plumose setae, two of them being twice as long as the others; ischium a little shorter than merus; carpus and propodus equal in length, dactylus with stout terminal seta, exopod present; pereiopod 1 basis shorter than rest of extremity, propodus second longest article after basis, exopod present; pereiopod 2 dactylus second longest article after basis, terminal seta shorter than dactylus, ischium not visible, propodus small, exopod present; pereiopod 3 carpus second longest article after basis, dactylus short with longer terminal seta, exopod present; pereiopod 4 carpus second longest article after basis, terminal seta longer than dactylus; pereiopod 5 carpus second longest article after basis, with two long distal setae reaching beyond tip of dactylus' terminal seta; uropod's peduncle longer than rami with 12 setae at inner margin, rami equal in length, exopod with eight plumose setae at inner and 13 stout setae at outer margin of distal article, endopod two-segmented, basal article a little shorter (factor 0.9) than distal, with seven setae at inner and one at outer distal margin, distal article with ten stout setae, the distal one being longer, one long terminal and one shorter subterminal seta.

Etymology

The new species is named after the tooth on the ocular lobe.

Remarks

The new species resembles *G. dentata* Hale, 1944. In Jones's (1984) species list, *G.* cf. *dentata* (identified by J. Day) is mentioned for Lizard Island. The specimens in the present collection differ from *G. dentata* by: presence of the large tooth at the distal tip of ocular lobe, which is missing in *G. dentata*; accessory flagellum of antenna 1 half as long as basal article of main flagellum, being shorter in *G. dentata*; uropod's endopod distal article a little longer than basal, but the distal being nearly half as long as basal one in *G. dentata*.

Genus ***Leptocuma*** Sars, 1873

Leptocuma longidactylum sp.n.
(Figure 16)

Material

North end Herald Bight, Shark Bay, 3 fathoms, sand, 'Isobel' W.H., 21 November 1945, submarine light, temperature: 24.22°C ; 30 males; SAM C 5992.

Holotype: male; SAM C 5991

Locus typicus: Australia, South Australia, north end Herald Bight, Shark Bay, 3 fathoms, sand, 'Isobel' W.H., submarine light, temperature: 24.22°C

Date: 21 November 1945

Diagnosis

Leptocuma with two spines at distal end of first pereiopod's basis, ischium of second pereiopod longer than carpus. Bases of the pereiopods in males more slender and longer, compared to the exopods' bases.

Description

Based on the holotype, adult male, 3.6 mm in length.

Carapace 0.9 mm in length, pseudorostral lobes not meeting in front of ocular lobe, siphonal tube

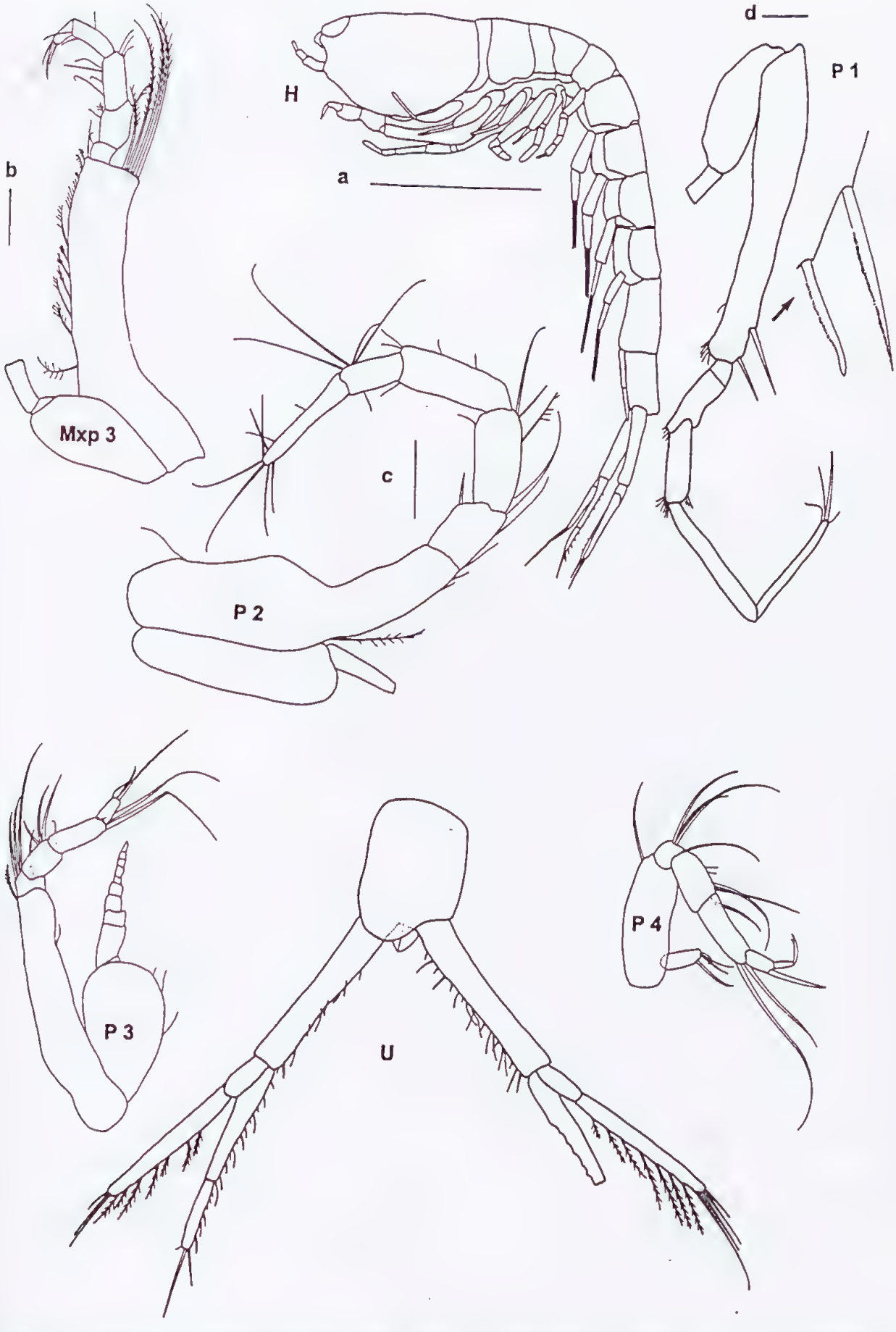

FIGURE 16: *Leptocuma longidactylum* sp.n. adult male: H: habitus, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, U: pleonite 6 and uropods. Scale a: 1 mm (H), scale b: 0.1 mm (Mxp 3, P3, P4), scale c: 0.1 mm (P2), scale d: 0.1 mm (P1, U).

very short, dorsomedian line straight, not pronounced; antennal notch wide and shallow, anterolateral margin rounded, anteroventral margin of carapace smooth; ocular lobe present, no lenses visible; free thoracic segments 0.8 mm in length, second thoracic segment longest; abdomen 1.9 mm in length, longer than carapace and free thoracic segments combined; pleonite 6 shorter than uropod's peduncle.

The description of the extremities is based on the paratype, adult male. Maxilliped 3 basis much longer than rest of extremity, wider than following articles, with four long, plumose setae, inner margin with short plumose setae and hair-like setae; merus a little wider than ischium and carpus, subequal in length to carpus and propodus, exopod present; pereiopod 1 basis longest article but shorter than rest of extremity, at distal inner margin a serrated seta preceded by a longer serrated seta, outer distal edge with hair-like setae; propodus second longest article, exopod present; pereiopod 2 basis longest article but shorter than rest of extremity, proximal part wider than distal, ischium longer than propodus, dactylus second longest article, tapering, exopod present; pereiopod 3 basis longer than rest of extremity, ischium with three long and one shorter distally annulated setae, merus with three annulated setae in distal part; carpus distally with two long simple setae, propodus and dactylus short, exopod present; pereiopod 4 basis longest article but shorter than rest of extremity, distally each article with long simple setae: basis one, ischium three, merus three, carpus two, propodus one stout, dactylus one terminal stout, exopod rudimentary; uropod's peduncle longer than pleonite 6 but shorter than rami, 9 to 19 setae at inner margin; exopod equal in length to endopod, inner margin with seven plumose setae, three terminal long simple setae; endopod two-segmented, proximal article 1.8 times longer than distal, proximal article with 13, distal article with six setae at inner margin, two long terminal and one short hair-like setae at outer distal edge.

Etymology

The new species is named after the long dactylus of the second pereiopod.

Remarks

Nine Australian *Leptocuma* species are described for the genus. According to Tafe & Greenwood (1996) they are divided into two groups:

- Group 1 with smooth strong setae at distomedial margin of first pereiopod's basis, propodus with well developed brush of setae at distal end, uropod's endopod proximal article shorter or only a little longer than distal. Only two of the Australian *Leptocuma* species are in this group: *L. pulleini* Hale, 1928 and *L. vicarium* Hale, 1944.
- Group 2 with serrated seta at distal end of first pereiopod's basis preceded by another serrated seta, distal end of propodus with few setae, uropod's endopod with distal article longer than proximal. The new species belongs to the second group. For South Australia only two *Leptocuma* species are described : *L. pulleini* Hale, 1928, belonging to group 1, and *L. sheardi,* Hale 1936, belonging to group 2.

The new species differs from *L. sheardi* in having the bases of the pereiopods in males more slender, and longer compared to the exopods' bases; the distal articles of the new species' pereiopods bear fewer long setae than those of *L. sheardi.* The most striking characters of the new species are the dactylus being longer than the carpus and the long ischium, both of the second pereiopod, which are unique within the genus.

Leptocuma sp.
(Figure 17)

Material

WA: 46, 1 ovigerous female; ZMH K 39935.

Description

Based on the strongly decalcified female, total length 3.3 mm.

Carapace shorter than five free thoracic segments, pseudorostral lobes not meeting in front of rounded ocular lobe; abdomen subequal in length to carapace and free thoracic segments combined; pleonite 6 a little (1.2 times) longer than wide, two anal valves visible, length proportion of uropod's peduncle to pleonite 6 is 1.5.

Maxilliped 3 basis longer than rest of extremity, slightly geniculated, distal half of inner margin with 14 plumose setae, distal outer margin sloping backwards, with five long plumose setae, exopod present; pereiopod 1 basis longest article, 0.77 as long as rest of extremity, inner margin with seven plumose setae, distal end of inner margin with two stout serrated spines, outer distal end with one short plumose seta, propodus second longest article, 1.1 times longer than slender dactylus,

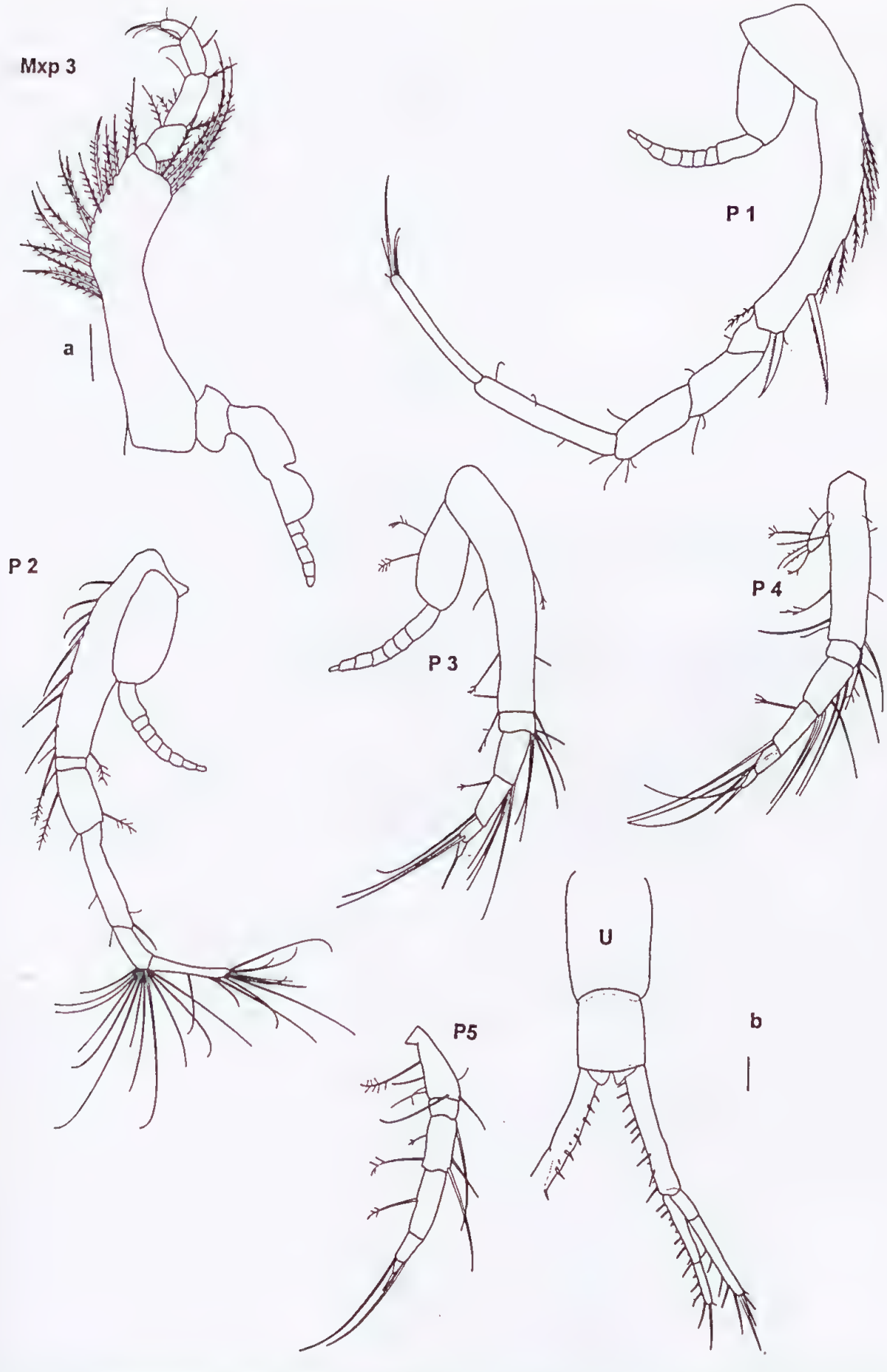

FIGURE 17: *Leptocuma* sp. female: Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 0.1 mm (Mxp3, P1, P2, P3, P4, P5), scale b: 0.1 mm (U).

TABLE 3: Comparison of *Leptocuma* species with two serrated spines at distal end of first pereiopod's basis in either sex.

Character	*L. barbarae*	*L. intermedium*	*L. kennedyi*	*L. obstipum*	*L. serriferum*	*L. sheardi*	*L.* sp.	*L. longidactylum* sp.n.
Length-proportions								
P1, propodus:dactylus	1.2	1.1	1.3	1.1	1.3	1.2	1.1	1.2
uropod's peduncle: endopod	0.9	?	0.9	1	0.9	1.1	1.1	0.9
uropod's endopod basal:distal	1.5	2.6	1.7	2.3f	1.6	2.0	1.2	1.8
longest ramus	exo		equal	equal	equal	equal		equal
P2, propodus:dactylus	0.6	1.3	0.5	0.8	0.6	0.8	0.7	0.6
Number of setae at uropod								
peduncle	18m, 11f	?	5–6m	23m, 16f	15f	17m, 14f	12f	19m
endopod proximal article	16m, 11f	16m	10–11m	16m, 17f	18f	14m, 9f	12f	13m
endopod distal article	8m, 9f	8m	4–5m	8m, 8f	11f	8m, 5f	6f	9m
Maxilliped 3, setae at basis								
inner margin	?	?		last 3/4	long at prox.,short at distal		14 at distal half	10
distal outer margin	?	?		8	6		5	4

m: male; f: female

exopod present; pereiopod 2 basis as long as merus, carpus and propodus combined, carpus second longest article, about twice as long as propodus, propodus with 12 hair-like setae at distal end, 0.68 times as long as tapering dactylus, dactylus with 11 terminal and subterminal hair-like setae, exopod present; pereiopod 3 basis longer than rest of extremity, carpus a little shorter than merus, which is second longest article, propodus and dactylus short, ischium, merus, carpus, and propodus distally with long terminal annulated setae, dactylus with one strong terminal seta, exopod present; pereiopod 4 similar to pereiopod 3, but basis shorter than rest of extremity, exopod rudimentary; pereiopod 5 basis much shorter than rest of extremity, carpus second longest article, fewer setae than preceding extremities, propodus with two long terminal setae. Uropod's peduncle with 12 unequal spiny setae at inner margin, 1.1 times longer than endopod; uropods' rami: exopod with five setae at inner, three at outer margin, and one seta each terminally and subterminally, a little longer than endopod; endopod two-segmented, basal article 1.2 times longer than distal, basal article with 11, distal article with four unequal setae at inner margin, one longer terminal seta.

Remarks

Five species of the genus *Leptocuma* are described with two serrated spines located distally at the basis of first pereiopod: *L. obstipum* Hale, 1944, *L. intermedium* Hale, 1944 both from New South Wales; *L. serriferum* Hale, 1944 from West Australia and New South Wales; *L. barbarae* Tafe & Greenwood, 1996 and *L. kennedyi* Tafe & Greenwood, 1996 both from Queensland. In *L. sheardi* Hale, 1944 described from South Australia, only males have two serrated spines at the basis of first pereiopod, females have one. The female of the Western Australian material is compared with the other species mentioned (Table 3). It does not fit with any of the described species, so it is probably new. It is not named because of the poor condition of the single specimen.

Genus *Picrocuma* Hale, 1936

Picrocuma poecilotum Hale, 1936

Material

Various stations, Noosa R., 40 mesh tow net, June 1940, leg. ISR Munro; 6 ovigerous females, SAM C 5993.

Remarks

The specimens from the collection of the South Australian Museum fit the most striking characters of *P. poecilotum* given in Hale (1936). These are the large second pereionite, the pseudorostral lobes meeting in front of ocular lobe, a dorsal hump seen in lateral view behind the ocular lobe in males and juveniles, and more posterior in ovigerous females. A comparison of the characters within the genus is given in Table 4.

TABLE 4: Comparison of *Picrocuma* species. l: length, w: width.

	Picrocuma poecilotum	*Picrocuma crudgingtoni*	*Picrocuma rectangularis* n.sp.
Carapace			
male l:w	1.8	1.7	1.7
female l:w	1.5	?	1.6
Dorsal humps	behind ocular lobe	pereionite 2	no
Uropods' endopods' setae			
male	12 + 1 long	6 + 1 long	8 + 1 long
female		3	4 + 1 long
Uropods' proportions			
peduncle l:w, male	3?	2?	4.5
peduncle l:w, female			3.5
endopod l:w, male	3.4	3.9	5.8
endopod l:w, female			3.1
peduncle:pleonite 6, male	1.5	1.4	1.8
peduncle:pleonite 6, female		1.3	1.5
endopod:peduncle, male	1.1	0.9	0.7

l: length; w: width

Picrocuma rectangularis sp.n.
(Figure 18)

Material

WA: 17+18: 7 males, 10 females;

Holotype: non-ovigerous female; ZMH K 39938.

Leg.: G. Hartmann & G. Hartmann-Schröder

Date: 20 September 1975

Locus typicus: Derby, silty lower eulitoral zone

Paratypes: WA-28, Port Hedland, 27 September 1975, fine sand on reef top, 2 males, 3 females, ZMH K 39939; 1 male, 2 females; SAM C 6081.

Diagnosis

Minute species of *Picrocuma*, uropod's peduncle slender, long compared to the other known species, uropods' rami with a rectangular shape.

Description

Based on holotype, female 1.4 mm in length.

Carapace smooth, shorter than free thoracic segments, proportion length to width 1.6; pseudorostrum as long as ocular lobe, siphonal tube not visible; dorsomedian line not pronounced; antennal notch not present; anterolateral margin smooth; anteroventral margin of carapace rounded. Integument, although decalcificated due to fixation in formalin, with a reticulate pattern visible in higher magnification; eye not pigmented.

Five free thoracic segments visible, the first slender, second long; abdomen shorter than carapace and free thoracic segments combined; pleonite 6 shorter than wide (0.9), shorter than uropods' peduncles, length proportion peduncle to pleonite 6 is 1.5.

Description of extremities based on paratype. First antenna basal article geniculated, distal article longest, accessory flagellum minute, main flagellum short, two-segmented, three distal setae.

Maxilliped 3 basis slightly geniculated, shorter than rest of extremity, carpus second longest article, dactylus with strong terminal and three hair-like subterminal setae, exopod present; pereiopod 1 basis shorter than rest of extremity, carpus second longest article, similar in shape to maxilliped 3, exopod present; pereiopod 2 basis shorter than rest of extremity, ischium missing, dactylus second longest article after basis; merus, carpus, and propodus decreasing in length, exopod present; pereiopod 3 with exopod, similar to pereiopods 4 and 5, basis shorter than rest of extremities, carpus second longest article; uropod's peduncle longer than rectangular rami, inner margin without armature, exopod longer than unsegmented endopod, exopod with one long and one short terminal spine, endopod with three spines at inner margin, one terminal spine 0.6 times as long as endopod.

Male 1 mm in length, similar to female, except for following characters: antenna 1 basal article not geniculated, basis of maxilliped 3 more slender, exopods' basal article more rounded than in female in all extremities, uropods' peduncles longer than in female, length proportion peduncle to pleonite 6 is 1.8, rami equal in length, endopod with eight spines at inner margin and one terminal longer one.

Etymology

The new species is named after the rectangular shape of its uropods' rami.

Remarks

Only two species are currently known in the genus *Picrocuma*: *P. poecilotum* Hale, 1936 from Queensland, Tasmania and South Australia and *P. crudgingtoni* Tafe & Greenwood, 1996 from Queensland. The main characters given by Tafe & Greenwood (1996) are compared in Table 4. The most important difference of the new species compared with the known ones is the uropods' rami having a rectangular shape, being longer in males than in females, the endopod having eight lateral plus one terminal spine; and the uropod's peduncle being longer compared to pleonite 6 than in the other two species.

Genus ***Vaunthompsonia*** Bate, 1858

Vaunthompsonia* cf. *cristata Bate, 1858

Material

Near Pt. Maclaren, Thorney Passage, Whiting Ground, 3.5 fathoms, 8-8.30 pm, 2 March 1941, submarine light, leg. K. Sheard: three males, SAM C 5994.

In this material the pereiopods are broken; however, one can infer the specimens are close to *V. cristata* based on the serrated margins of carapace and pleonite 6, and the anal valves each ending in a fine hair. All these characters are typical for this species.

Family LEUCONIDAE Sars, 1878

Genus ***Ommatoleucon*** Watling, 1991

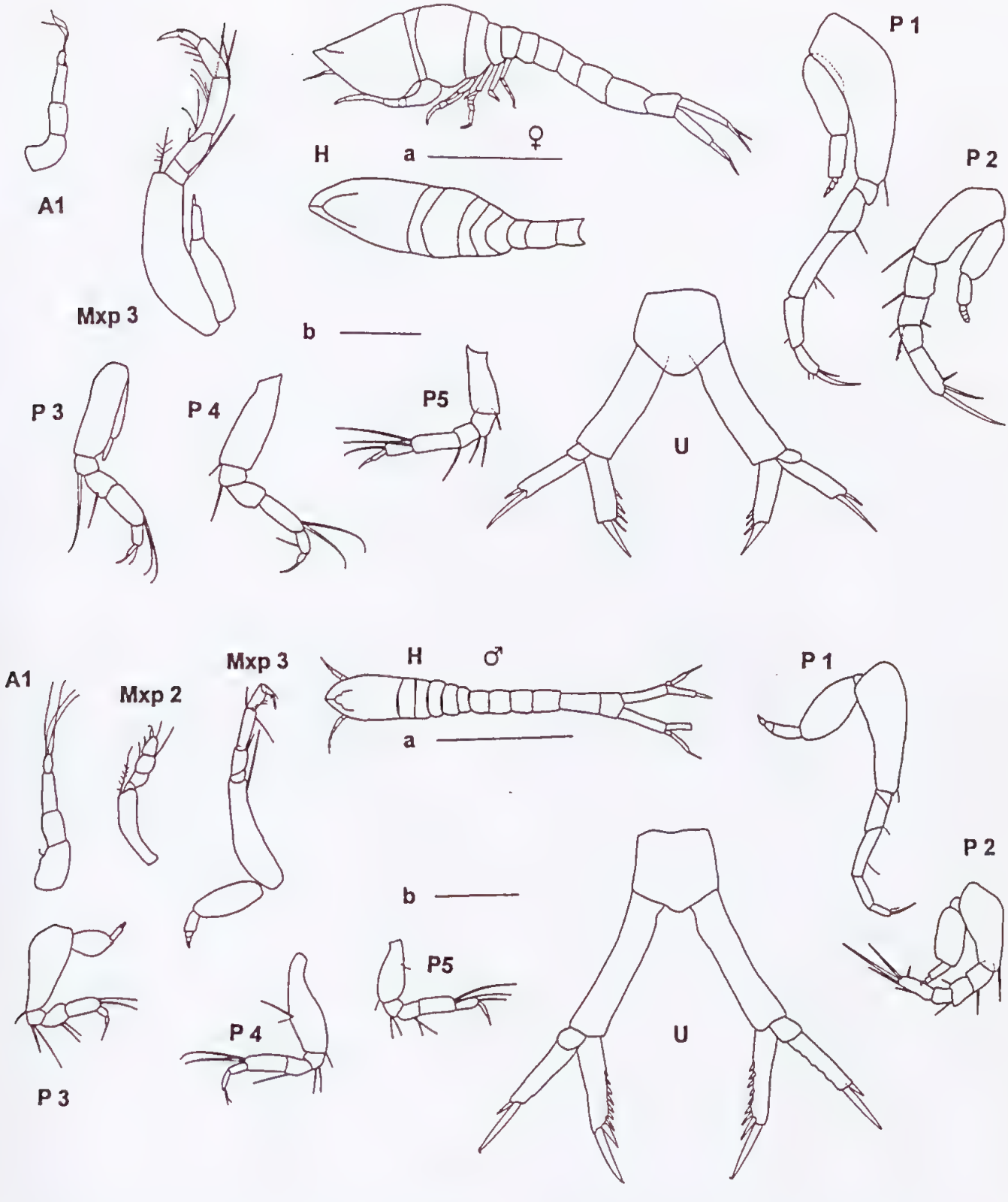

FIGURE 18: *Picrocuma rectangularis* sp.n. female (above): H: habitus, A1: first antenna, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 0.5 mm (H), scale b: 0.1 mm (A1, Mxp3, P1, P2, P3, P4, P5, U). *Picrocuma rectangularis* sp.n. male (below): H: habitus, A1: first antenna, Mxp2: maxilliped 2, Mxp3: maxilliped 3, P1: pereiopod 1, P2: pereiopod 2, P3: pereiopod 3, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 0.5 mm (H), scale b: 0.1 mm (A1, Mxp2, Mxp3, P1, P2, P3, P4, P5, U).

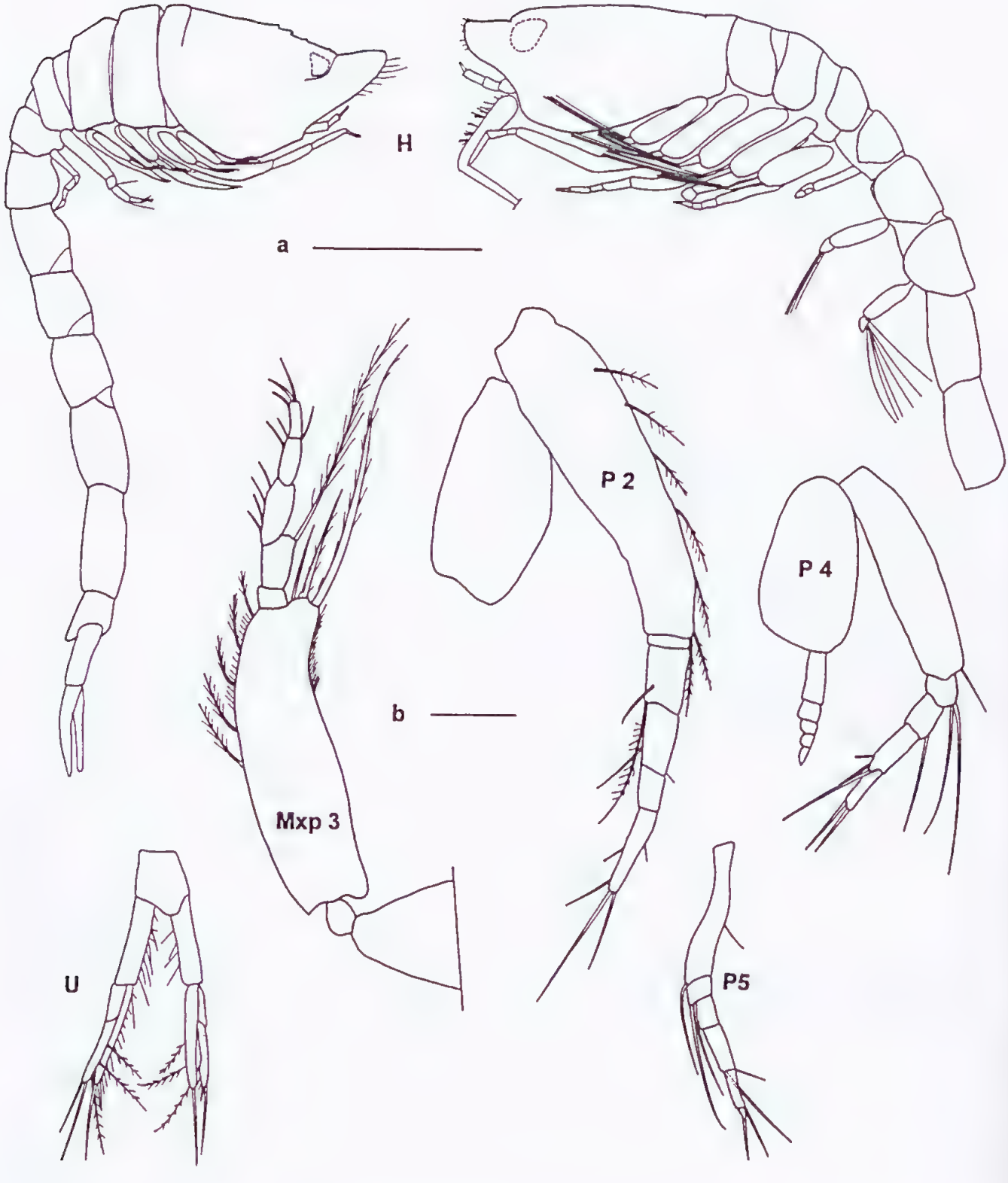

FIGURE 19: *Ommatoleucon ocularis*: H: habitus adult male (upper right) and subadult female (upper left), male's extremities: Mxp3: maxilliped 3, P2: pereiopod 2, P4: pereiopod 4, P5: pereiopod 5, U: pleonite 6 and uropods. Scale a: 0.5 mm (H, U), scale b: 0.1 mm (Mxp3, P2, P4, P5).

Ommatoleucon ocularis (Hale, 1945)
(Figure 19)

Material

TAS: Nubeena: 6 males, 2 subadult females; ZMH K 39937.

Remarks

The first record for members of the family Leuconidae from Tasmania fits well with the characteristics Hale (1945) gave for his new species, *Leucon ocularis,* which was transferred by Watling (1991) into his new genus *Ommatoleucon.* The diagnostic characters of this genus are: uropods' endopods unsegmented, straight pseudorostrum in front fringed with setae, ocular lobe not distinctly defined, eye present, pedigerous segments depressed, uropods' exopods with three unequal distal spines, inner margin with three plumose setae and a spine next to terminal three, endopod with 11 short spines at inner margin. The eye in the present specimens appears to be submerged in the carapace.

Distribution

South Australia, St. Vincent Gulf, 19 m; Tasmania, Nubeena, 0.5 m.

Acknowledgments

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AN ANNOTATED CHECKLIST OF THE AUSTRALIAN ACANTHOCEPHALA FROM MAMMALIAN AND BIRD HOSTS

LR SMALES

SMALES, LR. 2003. An annotated checklist of the Australian Acanthocephala from mammalian and bird hosts. *Records of the South Australian Museum* 36(1): 59–82.

A compilation of all the records of acanthocephalans parasitising Australian mammals and birds is presented, firstly as a parasite–host list and then as a host–parasite list. Current and original parasite and host names are given. References for and localities of each record are provided. Hosts from Australian sub-Antarctic and Antarctic waters are included but Papua New Guinea records are excluded.

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A list of type specimens of the Acanthocephala held in the South Australian Museum was compiled by Smales (1983), followed by a complete list of the Australian Acanthocephala by Edmonds (1989), more than 10 years ago. Since then new species have been described, additional material has been collected and many host and parasite taxa have been revised. It is, therefore, timely to produce updated lists that treat all the known acanthocephalans from Australian hosts.

This checklist is a compilation based on all published records up to 2002, augmented by the examination of all the specimens deposited in the Queensland Museum, Brisbane (QM); South Australian Museum, Adelaide (SAM); registration numbers prefixed as AHC, Australian Museum, Sydney (AM); the South Australian Research & Development Institute, Adelaide (SARDI); and the CSIRO Wildlife Collection, Canberra (CSIRO). It is limited to data from mammalian and bird hosts, including presumed paratenic hosts and accidental hosts; fish hosts are presently being reviewed (Pichelin, pers. comm.), amphibian hosts were recently treated by Barton (1994) and reptilian hosts by Pichelin et al (1999).

Although for the most part restricted to records of parasites from the Australian states, records from marine hosts collected from Australian sub-Antarctic and Antarctic territories have also been included. In these latter cases only material held in Australia is listed although the known distribution of such species may be circumpolar.

Parasite nomenclature is based on the system of classification of Amin (1985, 1987) and Golvan's (1994) alphabetical list of genera and species. Host nomenclature is based on Strahan (1995) for the mammals, and Marchant and Higgins (1990–2001) and Schodde and Mason (1999) for the birds.

Each record is given using the current parasite name followed by its synonyms. Because there have been numerous changes to the taxonomy of many species, all known synonyms of the parasite are listed although some earlier records could not be accessed directly. This is followed by each host, with localities, specific references to Australian material, and museum registration numbers. If the current name of the host differs from that used in the original reference it is given as 'host as ...' after the reference in the host–parasite list. The type host is designated by an asterisk.

The following abbreviations are used for localities: NSW (New South Wales), NT (Northern Territory), Q (Queensland), V (Victoria), T (Tasmania), SA (South Australia), WA (Western Australia).

PARASITE–HOST LIST

CLASS ARCHIACANTHOCEPHALA

Gigantorhynchidae Hamman, 1892

1. ***Mediorhynchus alecturae*** (Johnston & Edmonds, 1947)

Syns: *Echinorhynchus (Gigantorhynchus)* sp. Johnston, 1912; Johnston & Deland, 1929
Empodius alecturae Johnston & Edmonds, 1947
Empodisma alecturae Yamaguti, 1963
Mediorhynchus alecturae Golvan, 1962; Byrd &

Kellog, 1971; Schmidt & Kuntz, 1977; Smales, 2002a

Host: *Alectura lathami* Gray,* Q, Johnston 1912a: 106, 1912b: 72; Johnston & Deland 1929: 148; Smales 2002a: 375; AHC 1186, 2930, 4128, 2250, 427470-78, 42918-23.

2. ***Mediorhynchus colluricinclae*** Smales, 2002

Hosts: *Acanthochoera chrysoptera* (Latham), SA, Smales 2002a: 377-380; AHC 4627

Coluricincla harmonica (Latham)*, SA, Smales 2002a: 377-380; AHC 5081, 5102, 18796, 28396

Pomatostomus superciliosus (Vigors & Horsfield), SA, Smales 2002a: 377-380; AHC 5118

Rhipidura leucophrys (Latham), SA, Smales 2002a: 377-380; AHC 5040.

3. ***Mediorhynchus corcoracis*** Johnston & Edmonds, 1951

Syn: *Echinorhynchus* sp. Cleland, 1922; Johnston & Deland, 1929a

Hosts: *Corcorax melanoramphos* (Vieillot),* NSW, Q, SA, V, Cleland 1922: 108; Johnston & Deland 1929: 151; Johnston & Edmonds 1951:1-3; Smales 2002a: 375; AHC 3365, 3366, 3426, 5091, 6561, 23814, 42481-503

Corvus bennetti North, SA, Johnston & Edmonds 1951:1-3; Smales 2002a: 375; AHC 3269

Corvus coronoides Vigors & Horsfield, SA, Smales 2002a: 375; AHC 5086

Corvus mellori Matthews, SA, V, Smales 2002a: 375; AHC 5088, 5108, 5109, 11530, 18225

Corvus tasmanicus Matthews, Tas, AHC 4586, 4633.

Corvus sp. SA, AM W1056, W1065

'crow', SA, NT, Smales 2002a: 375; AHC 1056, 1065, 3361

Grallina cyanoleuca (Latham), SA, NT, Smales 2002a: 375; AHC 434, 18222.

4. ***Mediorhynchus robustus*** Van Cleave, 1916

Syns: *Mediorhynchus garruli* Yamaguti, 1939

Mediorhynchus robustus Van Cleave, 1916; Schmidt & Kuntz, 1977

Host: *Grallina cyanoleuca* (Latham), Q, Smales 2002a: 375; QM GL11212 Specimens collected by J.W. Fielding, 1912, identified by H.H. Baylis, 1926, are now missing. This identification is doubtful but cannot be confirmed.

5. ***Mediorhynchus*** sp. A

Host: *Stiltia isabella* Vieillot, NT, Smales 2002a: 375; CSIRO A21, identification by G. Schmidt but material missing from the collection.

6. ***Mediorhynchus*** sp. B

Hosts: *Acanthogenys rufogularis* Gould and 'gull', SA, Smales 2002a: 375; AHC 5126, 20640, 2 female specimens and 1 fragment only available for study.

7. ***Mediorhynchus*** sp. larvae

Presumed paratenic host: *Isoodon macrourus* (Gould), Q.

Moniliformidae

8. ***Australiformis semoni*** (Linstow, 1898)

Syns: *Echinorhynchus semoni* Linstow, 1898

Prosthenorchis s.l. semoni Travassos, 1917

Gigantorhynchus sp. Johnston, 1910a; Johnston & Deland, 1929

Gigantorhynchus semoni Porta, 1908; Johnston, 1909a, 1911; Johnston & Deland, 1929

Moniliformis semoni Johnston & Edmonds, 1952

Australiformis semoni Schmidt & Edmonds, 1989

Hosts: *Antechinus agilis* Dickman et al, AHC 19728-32, CSIRO A31, A36, A48, *Antechinus stuartii* Macleay, Schmidt & Edmonds 1989: 215-217

Isoodon macrourus (Gould), Q, NT, AHC 3416, 10512, 17994, 23308, 23309, 23316, CSIRO A5, A6, A9, A61, A67, A107, QM GL14429, GL14431, GL14433, GL14437, GL14438, GL14440, GL14441, GL14442, GL14443, GL14464, GL14465

Isoodon obesulus (Shaw),* NSW, Q, T, WA, Linstow 1898: 471; Johnston 1909a: 521; Johnston & Edmonds 1952: 215-217; Schmidt & Edmonds 1989: 215-217; AHC 4090, 8325, 17929, 17930, 17931, 17932, 17980-91, 18038, 18041, 18207, 18208 42513-22, CSIRO A90, A92

Perameles gunnii Gray, T, V, Schmidt & Edmonds 1989: 215-217; AHC 5036, 5037, 5049, 5087, 11424, 11430, 16348, 16350, 16351, 17928, 17992, 17993, 18039, 18117, 18175, 18213, 23302, 23305, 23317, 23320, 23322, 23327, 23328, 23329, 16348, 16350, 16351, 17928, CSIRO A2, A14

Perameles nasuta Geoffroy, NSW, Q, Johnston 1910: 27, 1911: 50; Johnston & Edmonds

1952: 215-217; Schmidt & Edmonds 1989: 215-217; AHC 5093, CSIRO A3, A7, A66, QM GL14430, GL14436, G211343

Phascogale tapoatafa (Meyer), NSW, Johnston 1910: 27, 1911:50; Johnston & Edmonds 1952: 18-20; Schmidt & Edmonds 1989: 215-217

Potorous tridactylus (Kerr), T, AHC 10069, 18577, 17995

Bandicoot, no locality data, Q, T, AHC 3394, 3395, 3404,7850, 17978, 17995, 18576.

9. ***Moniliformis moniliformis*** (Bremser, 1811)

Syns: *Echinorhynchus moniliformis* Bremser, 1811

E. grassi Deffke, 1891; *E. canis* Porta, 1914; *E. belgicus* Raillet, 1918

Gigantorhynchus Hamman, 1892 *pro parte*

Gigantorhynchus moniliformis Porta, 1908; Johnston, 1909b, 1909c, 1909d, 1912b, 1913, 1916; Nicoll, 1914

Hormorhynchus moniliformis Johnston, 1918a; Fielding, 1927; Southwell & McFie, 1925

Moniliformis moniliformis Travassos, 1915, *nec M. moniliformis sensu* Travassos, 1917 see Golvan, 1994; Johnston & Edmonds, 1952

Moniliformis dubius Meyer, 1932; Johnston & Deland, 1929; Meyer, 1933

Hosts: *Rattus rattus* (Linn.), NSW, Q, SA, Johnston 1909d: 583, 1909b: 218, 590, 1909c: 81, 1912b: 83, 1916: 43; Johnston 1918a: 69; Fielding 1927: 123; Southwell & McFie 1925: 171; Johnston & Deland 1929: 147; Johnston & Edmonds 1952: 20-21; AHC 42507, 42508, 42510

Rattus norvegicus (Berkenhout), NSW, Q, NT, SA, Johnston 1909b: 218, 590, 1909c: 81, 1912b: 83, 1913: 93, 1916: 43; Johnston 1918a: 69; Fielding 1927: 123; Southwell & McFie 1925: 171; Johnston & Deland 1929: 147; Johnston & Edmonds 1952: 20-21; Edmonds, 1989: 127; QM GL11008, GL11068, GL11091, GL14434, AHC 2486, 3419, 42504, 42505, 42506, 42509, 42511

Rattus fuscipes (Waterhouse) Edmonds, 1989: 128

rat, *Rattus spp.*, NSW, Q, Nicoll 1914: 4; AM W305, W1602, QM GL11572, GL11703, AHC 42512.

Oligocanthorhynchidae

10. ***Macracanthorhynchus hirudinaceus*** (Pallas, 1781)

Syns: *Taenia haeruca* Pallas, 1766 *pro parte*, *T. hirudinaceus* Pallas, 1781

Echinorhynchus hirudinaceus Pallas 1781; *E. gigas* Bloch, 1782

Gigantorhynchus hirudinaceus Porta, 1908; Johnston, 1909a, 1909c

Homorhynchus hirudinaceus Johnston, 1918b

Gigantorhynchus gigas Meyer, 1928

Macracanthorhynchus hirudinaceus Travassos, 1917; Johnston & Deland, 1929

Host: *Sus scrofa* Linn.,* Q, NSW, SA, V, Johnston 1909d: 583, 1909c: 79, 1918b: 216; Johnston & Deland 1929: 147; AHC 1596, 2471, 3422, 8480, 15473, 18500, 18903, 19018, 22539, AM W5549, W201622, SARDI A110.

11. ***Multisentis myrmecobius*** Smales, 1997

Host: *Myrmecobius fasciatus* Waterhouse,* WA, Smales 1997: 301-307; AHC 30021, 30022, 30034-35, 30091-93, 30096.

12. ***Oncicola pomatostomi*** (Johnston & Cleland, 1911)

Syns: *Echinorhynchus pomatostomi* Johnston & Cleland, 1911; Johnston & Deland, 1929

Echinorhynchus s.l. pomatostomi Petrochenko, 1958

Oligocanthorhynchus pomatostomi Tubangi, 1933

Oncicola sp. Banks, 1952; Edmonds, 1957a

Oncicola pomatostomi Schmidt, 1983

Paratenic hosts: *Acanthiza chrysorrhoa* (Quoy & Gaimard), SA, WA, Mawson et al 1986: 273

Amytornis purnelli Mathews, WA, Mawson et al 1986: 272

Anthochaera carunculata (White), WA, Mawson et al 1986: 274; AHC 4684

Anthus novaeseelandiae (Gmelin), WA, Mawson et al 1986: 266

Aphelocephala leucopsis Gould, SA, Cleland 1922: 108; Schmidt 1983: 397-399; CSIRO A34

Artamus cinereus Vieillot, NT, Q, Mawson et al 1986: 281; AHC 18217

Artamus superciliosus (Gould), Edmonds 1989: 128

Cinclosoma castonotus Gould, SA, Johnston & Deland 1929: 149; Schmidt 1983: 397-399

Cinclosoma cinnamoneum Gould, SA, NT, Johnston & Deland 1929: 149; Schmidt 1983: 397-399; Mawson et al 1986: 270; AHC 4896

Climacteris affinis (Blythe), AHC 18212

Climacteris leucopsis, AHC 1801

Climacteris melanura Gould, WA, Mawson et al 1986: 274; Schmidt 1983: 397-399

Climacteris picumnus Temminck, SA, Cleland 1922: 108; Johnston & Deland 1929: 150; Schmidt 1983: 397-399; AHC 5099

Colluricincla harmonica (Latham), SA, AM W1079

Cormobates leucophaea (Latham), SA, Johnston & Deland 1929: 151; Schmidt 1983: 397-399

Daphoenositta chrysoptera (Latham), NT, WA, Mawson et al 1986: 273; CSIRO A40, A47

Grallina cyanoleuca (Latham), NT, Mawson et al 1986: 281; AHC 5110

Gymnorhina tibicen (Latham), NT, SA, Mawson et al 1986: 282

Hylacola sp., no locality data, AHC 8863

Lalage leucomela (Vigors & Horsfield), NT, Mawson et al 1986: 267

Lichenostomus plumulus (Gould), WA, Mawson et al 1986: 276

Lichenostomus virescens (Viellot), WA, Mawson et al 1986: 276

Malurus cyaneus (Ellis), SA, AHC 28011

Manorina flavigula (Gould), NT, SA, WA, Mawson et al 1986: 275; CSIRO A32

Melanodryas cucullata (Latham), NT, Mawson et al 1986: 267

Microeca leucophaea (Latham), Q, Mawson et al 1986: 268

Nycticorax caledonicus (Gmelin), Q, CSIRO A46

Oreoica gutturalis (Vigors & Horsfield), NT, Mawson et al 1986: 269

Pachycephala inornata Gould, SA, Johnston & Cleland 1911: 115; Schmidt 1983: 397-399

Pachycephala rufiventris (Latham) NT, Mawson et al 1986: 268; Schmidt 1983: 397-399

Pedionomus torquatus Gould, SA, Johnston & Deland 1929: 148; Schmidt 1983: 397-399; AM W955

Petroica goodenovii Vigors & Horsfield, NT, CSIRO A33

Poephila cincta (Gould), Q, Mawson et al 1986: 279

Pomatostomus halli (Cowles), Q, CSIRO A57

Pomatostomus ruficeps (Hartlaub), SA, Johnston & Deland 1929: 150; Schmidt 1983: 397-399; AHC 557, 5072, CSIRO A56, SARDI A112-3

Pomatostomus superciliosus (Vigors & Horsfield), (*paratenic), NT, Q, SA, WA, Johnston 1910: 107; Johnston & Cleland 1911: 112; Cleland 1922: 107; Schmidt 1983: 397-399; AHC 1729, 1804, 2707, 5054, 5074, 5077, 5078, 42537, 42538, AM W293, CSIRO A27

Pomatostomus temporalis (Vigors & Horsfield), NSW, NT, Q, WA, Johnston & Cleland 1911: 112; Cleland 1922: 108, Mawson et al 1986: 270; Schmidt 1983: 397-399; AHC 18459, CSIRO A104, SARDI A112-9

Sericornis brunneus (Gould), SA, WA, Johnston & Deland 1929: 150; Mawson et al 1986: 272; AHC 28012, 28013, AM W1080

Sericornis cautus (Gould), SA, Mawson et al 1986: 272

Sericornis fuliginosus (Vigors & Horsfield), WA, Mawson et al 1986: 272; CSIRO A26

Sericornis pyrrhopygius (Vigors & Horsfield), SA, Johnston & Cleland 1911: 112; Schmidt 1983: 397-399; AHC 1802

Strepera versicolor (Latham), SA, CSIRO A60

Turnix castanota (Gould), SA, Mawson et al 1986: 246; AHC 5073

Turnix velox (Gould), Q, Mawson et al 1986; 246

Zoothera dauma (Latham), Q, SA, Schmidt 1983: 397-399; AHC 3369

Zoothera lunulata (Latham), Schmidt, 1983: 397-399

bird, SA, WA, AM W889, W1078

Definitive hosts: *Felis catus* Linn.,* NSW, NT, SA, V, Schmidt 1983: 397-399; AHC 9565, 15077, 18196, 18444-48, 18460, 18462-67, 30181-93, 30438, CSIRO A12, SARDI A112 -2, 4-8

Canis familiaris dingo Blumenbach, NT, Edmonds 1957a: 79; Schmidt 1983: 397-399; AHC 18443,18461, SARDI A112-1.

CLASS PALAEACANTHOCEPHALA

Centrorhynchidae

13. ***Centrorhynchus asturinus*** (Johnston, 1912)

Syns: *Gigantorhynchus* (*sensu latum*)Travassos, 1917

Gigantorhynchus asturinus Johnston, 1912a, 1913

Centrorhynchus asturinus Johnston, 1918b; Travassos, 1926; Southwell & McFie, 1925; Johnston & Deland, 1929; Golvan, 1956a; Petrochenko, 1958; Yamaguti, 1963 as *C. asturinum*

Echinorhynchus bazae Southwell & McFie, 1925

Prosthorhynchus bazae Travassos, 1926

Gordiorhynchus falconis Johnston & Best, 1943; Petrochenko, 1958

Centrorhynchus falconis Golvan, 1956a

Hosts: *Accipeter cirrocephalus* (Vieillot), NSW, Q, Southwell & McFie 1925: 163; Johnston & Deland 1929: 148; QM GL11509

Accipeter fasciatus (Vigors & Horsefield), NSW, NT, SA, Southwell & McFie 1925: 163; Johnston & Deland 1929: 148; AHC 3377, 8860, 42208-09

Accipeter novaehollandiae (Gmelin),* Q, Johnston 1912a: 108, 1913: 93; Southwell & McFie 1925: 164; AHC 950, 42203, 42205-07, QM GL11064, GL11213, G213458

Aviceda subcristata (Gould), NSW, Q, Johnston 1918: 215; Southwell & McFie 1925: 177; AHC 3371

Circus approximans Peale, NSW, Q, SA, Johnston 1918: 216; Mawson et al 1986: 244

Falco berigoria Vigors & Horsfield, NSW, NT, Q, SA, Southwell & McFie 1925: 164; Johnston & Deland 1929: 148; Mawson et al 1986: 245; AHC 5039, 5080, 19594, 42213-13, QM GL11200

Falco cenchroides Vigors and Horsfield, Q, SA, Mawson et al 1986: 246; AHC 5119, 5817, 19595

catbird or crested hawk, AHC 8874.

14. ***Centrorhynchus bancrofti*** (Johnston & Best, 1943)

Syns: *Echinorhynchus* sp. Johnston, 1912

Gordiorhynchus sp. Johnston, 1918; *Gordiorhynchus bancrofti* Johnston & Best, 1943

Centrorhynchus bancrofti Golvan, 1956a

Presumed paratenic hosts: *Antechinus agilis* Dickman et al, NSW, V, AHC 16299, CSIRO A17, A30, A35, A39, A43, A73, A78, A81, A85, A86, A88

Antechinus stuartii Macleay, NSW, QM G213754

Antechnius swainsonii (Waterhouse), NSW, CSIRO A23, A25, A72, A82, A84

Hosts: *Ninox boobook* (Latham), NSW, Q, SA, Johnston 1912a: 109; Johnston 1918b: 216; AHC 42210-11

Ninox strenua (Gould),* Q, Johnston & Best 1943: 226; Mawson et al 1986: 262; AHC 5060, 5101, 5114, 18057, CSIRO A68.

15. ***Centrorhynchus horridus*** (Linstow, 1897)

Syns: *Echinorhynchus horridus* Linstow, 1897; Marval, 1905

Echinorhynchus sp. Johnston, 1910b; Johnston & Deland, 1929

Prosthorhynchus horridus Travassos, 1926

Centorhynchus horridus Meyer, 1932; Johnston & Edmonds, 1948, 1958; Golvan, 1956a; Yamaguti, 1963, as *C. horridum*

Hosts: *Dacelo novaeguineae* (Hermann), Q, SA, Mawson et al 1986: 264; AHC 941, 5098, 18044, 42224-25, QM G207576

Todiramphus macleayii (Jardine & Selby), Q, CSIRO A65

Todiramphus sanctus (Vigor and Horsfield),* Q, Johnston 1910b: 105; Johnston & Edmonds 1948: 69; AHC 5057, 5124, 18802, 42214-23, QM G207319, G207575

Dacelo sp., Q, AHC 5130, 18187

kookaburra, Q, QM G207282.

16. ***Centrorhynchus*** sp. A

Host: egret, Q, single immature specimen; proboscis armature not consistent with described species from Australian localities, QM G207066.

17. ***Centrorhynchus*** sp. B

Hosts: kingfisher, no locality data, AHC 5123

hawk, no locality data, AHC 5134.

18. ***Centrorhynchus*** spp.

Presumed paratenic hosts: *Antechinus agilis* Dickman et al, NSW, V, CSIRO A35, A42, A79, A87, A105

Antechinus swainsonii (Waterhouse) NSW, CSIRO A18, A37

Phascogale tapoatafa (Meyer), NSW, CSIRO A103

Sminthopsis leucopus (Gray), T, CSIRO A22.

Plagiorhynchidae

19. ***Plagiorhynchus charadrii*** (Yamaguti, 1939)

Syn: *Prosthorhynchus charadrii* Yamaguti, 1939; Johnston & Edmonds, 1947

Plagiorhynchus charadrii Van Cleave, 1951 *nec* Golvan, 1956b; Schmidt and Kuntz, 1966; Smales, 2002b

Hosts: *Acridotheres tristis* Linn., V, Smales 2002b: 210; AHC 8648

Centropus phasianus Latham, Q, Smales 2002b: 210; AHC 1790, 1793, 1796 *Charadrius alexandrius* Linn., SA, T, Smales 2002b: 210; AHC 5046, 5061, 5070 *Charadrius ruficapillus* Temminck, SA, T, Mawson et al 1986: 251; AHC 5116, 18040, 18191

Haematopus fuliginosus Gould, T, Smales 2002b: 210; AHC 7731

Haematopus longirostris Vieillot, T, Smales 2002b: 210; AHC 7730

Pachyptila tutur (Kuhl), T, Smales 2002b: 210; AHC 8862

Thinornis rubricollis (Gmelin), V, SA, Johnston & Edmonds 1947: 561; AHC 3362, 5075, 5083, 15595, 18779, 42426-37

Turdus merula Linn., T, Smales 2002b: 210; AHC 8876.

20. ***Plagiorhynchus cylindraceus*** (Goeze, 1782)

Syns: *Echinorhynchus cylindraceus* Goeze, 1782; *E. brumpti* Blanc and Cauchemez, 1911; *E. pici* Gmelin, 1791; *E. musicapae* Rudolphi, 1819; *E. dimorphocephalus* Westrumb, 1821; *E. obliquis* Dujardin, 1845; *E. pigmentatus* Marval, 1902

Centrorhynchus cylindraceus Schrank, 1788; Travassos, 1926; Petrochenko, 1958

Prosthorhynchus Kostylev, 1915; Yamaguti, 1963 as *P. cylindraceus*; Golvan, 1956a, 1956b; Edmonds, 1982

Prosthorhynchus genitopapillatus Lundstrom, 1942 see Golvan, 1994

Prosthorhynchus upupae Lopéz-Neyra, 1946

Plagiorhynchus cylindraceus Schmidt and Kuntz, 1966; Schmidt, 1981; Amin et al, 1999; Smales, 1988, 2002b

Presumed paratenic hosts: *Antechinus agilis* Dickman et al, NSW, CSIRO A74

Hydromys chrysogaster, Geoffroy; Edmonds 1989: 130; AHC 19690

Isoodon obesulus (Shaw); T, Smales 1988: 1062-4; AHC 18827, 18988, 19013, 19014, CSIRO A94, A95

Isoodon macrourus (Shaw), ACT, CSIRO A93

Perameles gunnii (Gray), T, CSIRO A96

Wallabia bicolor (Desmarest), NSW, AHC 7307

Sminthopsis leucopus (Gray), V, AHC 6559

Potorous tridactylus (Kerr), T, CSIRO A108

Vulpes vulpes Linn., V, AHC 6555

Hosts: *Acridotheres tristis* Linn., V, Edmonds 1989: 130; AHC 18034, 23847

Corvus coronoides Vigors & Horsfield, V, Smales 2002b: 210; AHC 18812, 18825 *Gallina tenebrosa* Gould, V, Smales 2002b: 210; AHC 18087

Grallina cyanoleuca (Latham), V

Gymnorhina tibicen (Latham), T, V, Smales 2002b: 210; AHC 8877, 18035, 18226, 19046

Megalurus timoriensis Wallace, Johnston & Deland 1929: 150; doubtful record

Sturnus vulgaris Linn., T, V, Smales 2002b: 210; AHC 18186, 18203, 19426, 23849 *Threskiornis molucca* (Cuvier), T, Smales 2002b: 210; AHC 18182, 18205

Turdus merula Linn., T, V, Edmonds 1989: 130; AHC 8879, 10011, 11381, 18033, 23850, 23851

Vanellus miles (Boddaert), T, V, Smales 2002b: 210; AHC 18021

Zoothera lunulata (Latham), V, AHC 32105

pigeon, Schmidt 1981: 597; AHC 23848

Hydromys chrysogaster Geoffroy; T, AHC 18183, 18209

Perameles gunnii (Gray), T, Smales 1988: 1062-64; AHC 18184, 18206, 19012

21. ***Plagiorhynchus menurae*** (Johnston, 1912)

Syns: *Echinorhynchus menurae* Johnston, 1912b

Prosthorhynchus menurae Travassos, 1926; Meyer, 1933; Johnston & Best, 1943; Petrochenko, 1958, attributed in error to Schaston, 1912

Plagiorhynchus menurae Golvan, 1956; Schmidt and Kuntz, 1966; Smales, 2002b

Hosts: *Menura alberti* Bonaparte, NSW, Smales 2002b: 21; CSIRO A100, A101

Menura novaehollandiae Latham,* NSW, V, Johnston 1912b: 88; Johnston & Best 1943: 226; AHC 6552, 17951, 17952, 17976, 18045, 18575, 22934, 32135, 42438-41, CSIRO A50, A51, A52, A69, A70, A71, A89, A91.

22. ***Plagiorhynchus*** sp. Smales, 2002: 210

Hosts: *Psophodes olivaceus* (Latham), NSW, CSIRO A55

Ptiloris victoriae Gould, Q, CSIRO A63.

23. ***Plagiorhynchus*** spp.

Possibly *P. cylindraceus* but cyst forms difficult to determine with certainty

Presumed paratenic hosts: *Antechinus agilis* Dickman et al, NSW, CSIRO A24, A41 *Antechinus stuartii* Macleay, NSW, QM GL 12584 slide no 213755

Isoodon macrourus (Shaw), ACT, CSIRO A98

Isoodon obesulus (Shaw), ACT, CSIRO A95

Sminthopsis leucopis, NSW, CSIRO A19.

24. ***Porrorchis hylae*** (Johnston, 1914)

Syns: *Echinorhynchus* sp. Johnston, 1912b

Echinorhynchus hylae Johnston, 1914; Petrochenko, 1958 as *Echinorhynchus s.l. hylae*; *E. bulbocaudatus* Southwell & McFie, 1925; Johnston and Deland, 1929; *E. centropusi* Tubangi, 1933

Prosthorhynchus bulbocaudatus Travassos, 1926

Gordiorhynchus hylae Johnston and Edmonds, 1948

Pseudoporrorchis hylae Joyeaux and Baer, 1935; Edmonds, 1957a

Porrorchis hylae Schmidt & Kuntz, 1967; Smales, 2002b

Presumed paratenic host: *Antechinus stuartii* Macleay, NSW, QM GL 12584 Slide No 213753, GL12593

Hosts: *Burrhinus grallarius* (Latham), Q, Smales 2002b: 210; QM G207024

Centropus phasianus (Latham),* NT, Q, WA, AHC 5064, 5103, 5121, 18216, 18838 CSIRO A64, QM GL11402, G207272, G207473; Johnston & Deland 1929: 149; Edmonds 1957a: 76; Mawson et al 1986: 262; Smales 2002b: 210

Podargus strigoides (Latham), NT, Q, SA, Johnston & Edmonds 1948: 74; Mawson et al 1986: 263; Smales 2002b: 210; AHC 857, 3411 (listed as types in the register but the species was first described from *C. phasianus*), 4606, 5084, 5129, 6553, 6562, 11214 15221, 18211, 18218, 18220, 18221, 42542-47, QM G207057, G207103, G207193.

25. ***Porrorchis hydromuris*** (Edmonds, 1957)

Syns: *Pseudoporrorchis hydromuris* Edmonds, 1957a

Porrorchis hydromuris Schmidt and Kuntz, 1967; Smales, 2002b

Hosts: *Hydromys chrysogaster* Geoffroy,* Q, Edmonds 1957a: 77; Smales 2002b: 210; AHC 3398, 3402,5056, 5079, QM GL14411, GL14432, GL14435, GL14460-63, GL14466

rat, QM GL14374.

26. ***Porrorchis*** sp.

Host: *Felis catus* Linn., NSW, possibly Q, Smales 2002b: 210; AHC 3414, QM GL12464.

Polymorphidae

27. ***Andracantha clavata*** (Goss, 1940)

Syns: *Corynosoma clavatum* Goss, 1940; Johnston & Best, 1942; Johnston & Edmonds, 1953; Edmonds, 1955, 1957; Zdzitowiecki, 1986a, 1986b; Edmonds, 1989

Andracantha clavata: Zdzitowiecki, 1989, 1991

Hosts: *Cygnus atratus* (Latham), SA, AHC 3002, 3016

Eudyptula minor (Forster),V

Leucocarbo atriceps (King), Heard Is., Macquarie Is., Edmonds 1955: 141, 1957: 96; AHC 18021, CSIRO A20

Leucocarbo colensoi Buller, Auckland Is., Campbell Is., Johnston & Edmonds 1953: 59

Leucocarbo fuscescens Viellot, SA, AHC 5058, 11213

Phalacrocorax melanoleucos Viellot, V, SA, WA, Goss 1940: 12; Mawson et al 1986: 232; AHC 3384

Phalacrocorax sulcirostris (Brandt), SA, WA, Goss 1940: 12; Mawson et al 1986: 231; AHC 18359

Phalacrocorax varius (Gmelin),* SA, WA, Goss 1940: 12; Johnston & Best 1942: 252; AHC 2698, 15434, 42274

Phalacrocorax verrucosus (Cabanis), Kerguelen Is., Edmonds 1957b: 96

Phalacrocorax sp. Macquarie Is., AHC 18468

shag, WA, Goss 1940: 12-13; WAM WA73-83

Accidental host: *Arctocephalus pusillus* (Schreber), SA, Johnston & Best 1942: 253; AHC 22536.

28. ***Andracantha*** sp.

Identified as *Corynosoma phalacrocoracis* Yamaguti, 1939: 337-338 now *Andracantha phalacrocoracis*, Schmidt, 1975: 618-619. Specimens possibly collected on the British, Australian and New Zealand Antarctic Expedition of 1929-31. Probosces missing, therefore identification can't be confirmed.

Host: *Leucocarbo atriceps* (King), 'Antarctic' AHC 22639.

29. ***Arthmorhynchus johnstoni*** Golvan, 1960

Syns: *Arythmorhynchus frassoni* Johnston & Edmonds, 1951

Arythmorhynchus johnstoni Golvan, 1960; Edmonds, 1971

Host: *Numenius madagascarensis* (Linn.),* Q, Johnston & Edmonds 1951: 3; Edmonds 1971: 60; AHC 22554, 42183, 42184, AM W4571, QM GL11209 (specimen missing).

30. ***Arythmorhynchus limosae*** Edmonds, 1971

Host: *Limosa lapponica* (Linn.),* Q, Edmonds 1971: 58; AHC 42185-89, QM GL12403,

GL12406, GL12415, GL12445, G213743, G213744.

31. ***Bolbosoma baleanae*** (Gmelin, 1790)
Syns: *Sipunculus lendix* Phipps, 1774
Echinorhynchus balaenae Gmelin, 1790, *E. porrigens* Rudolphi, 1814; *E. mysticeti* Beneden, 1870
Bolbosoma balanae Van Cleave, 1953 in error, see Golvan, 1994
Bolbosoma porrigens Johnston & Deland, 1929; Meyer, 1932
Bolbosoma balaenae Petrochenko, 1958; Zdzitowiecki, 1991
Hosts: *Balenoptera acutorostrata* Lacépède, Antarctic/ Pacific, AHC 30160, 30162 *Globiocephala melas* (Traill), SA, AHC 3423
whale probably *Megaptera novaeangliae* (Borowski), NSW, Johnston & Deland 1929: 147; AHC 3423, 22544, AM G11124.

32. ***Bolbosoma capitatum*** (Linstow, 1880)
Syns: *Echinorhynchus capitatus* Linstow, 1880
Bolborhynchus capitatus Porta, 1906
Bolbosoma capitatum Porta, 1908; Meyer, 1932; Edmonds, 1957a, 1987; Amin & Margolis, 1998
Hosts: *Balaenoptera musculus* Linn., SA, AHC 18826
Globicephala melas (Traill) *Globicephala* sp., T, SA, Edmonds 1957a:78; AHC 11432
Pseudorca crassidens Owen, WA, SA, Edmonds 1957a; 78, 1987: 317; AHC 16308, 17979, 30159, WAM WA405-86
Physeter catodon Linn., T, AHC 10571
Accidental hosts: *Arctocephalus foresteri* (Lesson), SA, AHC 19697
Arctocephalus pusillus doriferus (Schreber), V, T, AHC 32114, 32126, 32132.

33. ***Bolbosoma turbinella*** (Diesing, 1851)
Syns: *Echinorhynchus balaenocephalus* Owen, 1803 see Golvan, 1994; *E. turbinella* Diesing, 1851
Bolborhynchus turbinella Porta, 1906
Pomphorhynchus turbinella Lieper & Atkinson, 1915 see Yamaguti, 1963
Bolbosoma turbinella Porta, 1908; Travassos, 1926; Baylis, 1929; Zdzitowiecki, 1991
Host: *Balaenoptera musculus* Linn., SA, AHC 18826.

34. ***Bolbosoma vasculosum*** (Rudolphi, 1819)
Syns: *Echinorhynchus vasculosus* Rudolphi, 1819; *E. auranticus* Risso, 1826; Diesing, 1851; *E. pellucidus* Leukart, 1828; *E. annulatus* Molin, 1858; *E. serrani* Linton, 1888, juvenile worm, may be synonym, see Golvan, 1994; *E. bifasciatus* Lühe, 1904
Bolbosoma aurantiacum Van Cleave, 1924; Travassos, 1926
Bolbosoma vasculosum Porta, 1908: 273-274; Petrochenko, 1958
Host: *Mesoplodon bowdoini* (Andrews), NT, SA, AHC 30133
Accidental host: *Arctocephalus pusillus doriferus* (Schreber) T, AHC 32106.

35. ***Bolbosoma*** sp.
Host: *Pseudorca crassidens* (Owen), no locality data, AHC 30351

36. ***Corynosoma arctocephali*** Zdzitowiecki, 1984
Corynosoma singularis Skryabin & Nikolsky, 1971 *pro parte*; Hoberg, 1986
Corynosoma arctocephali Zdzitowiecki 1984a, 1986a, 1991; Hoberg, 1986
Host: *Arctocephalus pusillus doriferus* (Schreber), Heard Island, AHC 12773.

37. ***Corynosoma australe*** Johnston, 1937
Syns: *Corynosoma otarinae* Morini & Boreo, 1960
Corynosoma australe Johnston, 1937; Johnston & Edmonds, 1953; Vargara & George-Nacimento, 1982; Zdzitowiecki, 1984a, 1986a, 1989; Smales, 1986; Pereira & de Matos Neves, 1993
Hosts: *Arctocephalus forsteri* (Lesson), SA, AHC 19589, 30107, 41273
Arctocephalus pusillus doriferus (Schreber), V, SA, AHC 10047, 18763, 18886, 18941, 18945, 18947, 19119, 19384, 22345, 30107, 30134, 32115, 32129
Arctocephalus tropicalis (Gray), V (Zoo), SA, AHC 22972, 32108
Arctocephalus sp., SA, AHC 18931, 18934
Hydrurga leptonyx (Blainville) Auckland Is., Campbell Is., Johnston & Edmonds 1953: 58; Smales 1986: 94; AHC 42235, 42236
Mesoplodon layardi (Gray), SA, AHC 24768
Neophoca cinerea (Peron),* SA, Johnston 1937: 13; Smales 1986: 94; AHC 15474, 22824, 23088, 30114, 31367, 42226-29, 42237, 32115, 32116, 32119

Phocarctos hookeri (Gray); Auckland Is., Campbell Is., Johnston & Edmonds 1953: 58; Smales 1986: 94; AHC 42231-34

Tursiops truncatus Montagu, V, AHC 24757, 32121

Accidental hosts: *Eudyptula minor* Forster, V

Leucocarbo atriceps (King), Heard Is., AHC 42279, 42280.

38. ***Corynosoma bullosum*** (Linstow, 1892)

Syns: *Corynosoma mirabilis* Skryabin, 1966

Echinorhynchus bullosus Linstow, 1892;

Corynosoma strumosum sensu Gower, 1939 see Yamaguti, 1963

Corynosoma singularis Skryabin & Nickolsky, 1971, *pro parte*

Corynosoma bullosum Raillet & Henry, 1907; Baylis, 1929; Travassos, 1926; Johnston & Edmonds, 1953; Edmonds, 1955, 1957b; Zdzitowiecki, 1984a, 1986a, 1991; Hoberg, 1986

Hosts: *Mirouga leonina* Linn.,* Crozet Is., Heard Is., Macquarie Is., Marion Is., Johnston & Edmonds 1953: 55; Edmonds 1995: 142; Edmonds 1957b: 96; AHC 3396, 3804-10, 32107, 32131, 42240-65

Hydrurga leptonyx (Blainville), Heard Is., QM G213756-63

Accidental host: *Delphinus delphis* Linn., WA, AHC 18883.

39. ***Corynosoma cetaceum*** Johnston & Best, 1942

Syns: *Echinorhynchus* sp. Krefft, 1871

Corynosoma sp. Johnston & Deland, 1929

Corynosoma cetaceum Johnston & Best, 1942; Figueroa & Puga, 1990; Aznar et al, 1999

Polymorphus cetaceus Schmidt & Dailey, 1971

Polymorphus arctocephali Smales, 1986; Edmonds, 1989

Hosts: *Arctocephalus pusillus doriferus* (Schreber), SA, V, Smales 1986: 97-99; Aznar et al 1999: 59-70; AHC 13787, 14835, 23344, 33112, 32128, 32130, 32132, 32109, 32110, 43654-57

Delphinus delphis Linn.,* SA, V, Johnston & Deland 1929: 149; Johnston & Best 1942: 250; AHC 3418, 18883, 30157, 40963, 40964, 42266-71

Hydrurga leptonyx (Blainville), V (Zoo)

Leptonychotes weddelli (Lesson), Antarctic, AHC 18025

Tursiops truncatus (Montagu), SA, V, Johnston & Best 1942: 250; AHC 1778, 3602, 18362, 18678, 18743, 18949, 18951, 18970, 19646, 19950, 19952, 19959, 22831, 22838, 22839, 24757, 26198, 30111, 30144, 30145, 30156, 30328, 30331 30332, 32122-24, 32111, 32117, 32121, 32125, 32127, 42272, 42273

seal, Q (Zoo), QM G207090.

40. ***Corynosoma pseudohammani*** Zdzitowiecki, 1984

Syns: *Corynosoma antarcticum* Johnston & Best, 1937 *nec C. antarcticum* Rennie, 1906

Corynosoma hammani Edmonds, 1957b, possibly a mixed infection of *C. hammani* and *C. pseudohammani*, see Zdzitowiecki, 1984b

Corynosoma pseudohammani Zdzitowiecki, 1984b, 1986a, 1991; Hoberg, 1986

Hosts: *Leptonychotes weddelli* (Lesson),* Adelie Land, Enderby Land, Johnston & Best 1937:10-12; Edmonds 1957b: 96; AHC 18020, 42238, 42239, 42291-93, 42296, 42297, AM W2872

Hydrurga leptonyx Blaineville, No locality data, AHC 42298, 42299.

41. ***Corynosoma shakletoni*** Zdzitowiecki, 1978

Host: *Pygoscelis papua* Forster, Macquarie Is., Edmonds 1955: 141; Zdzitowiecki 1985: 11; Hoberg 1986: 202; AHC 5067, CSIRO A38.

42. ***Corynosoma stanleyi*** Smales, 1986

Hosts: *Hydromys chrysogaster* Geoffroy,* Q, T, V, Smales 1986: 92-94; Smales & Cribb 1997: 449-450; AHC 8878, 15642, 15643, 15660, 18163, 18768, 22343, 27791, 27792, 30432, 43539, 43540.

43. ***Polymorphus biziurae*** Johnston & Edmonds, 1948

Nickol, Crompton & Searle, 1999 [Nickol et al comment generic assignment of *P. biziurae* is difficult because the putative intermediate host is a crustacean]

Hosts: *Biziura lobata* (Shaw),* NSW, SA, Johnston & Edmonds, 1948: 71-74; AHC 625, 3375, 3387, 3424, 5106, 7489, 19404, 42443-47, 424450-59

Cygnus atratus (Latham), SA, Mawson et al, 1986: 238; AHC 3391

Pelicanus conspicillatus Temminck, SA, Mawson et al 1986: 228

Phalacrocorax sulcirostris (Brandt), SA, AHC 3382, 42449

Phalacrocorax melanoleucos (Vieillot), SA, AHC 3384, 3389

Platalea flavipes Gould, SA, V, AHC 3388, 24061, 42455, 42457

Larus novaehollandiae Stephens, SA, AHC 3385

Threskiornis molucca (Latham), SA, T, AHC 3383, 3390, 5050, 13292, 42448, 42545, 42458.

44. ***Polymorphus brevis*** (Van Cleave, 1916)

Syn: *Arythmorhynchus brevis* Van Cleave, 1916b, 1945; Travassos, 1926; Golvan, 1960; Amin, 1985 as *A. breve*

Polymorphus brevis Meyer, 1933; Amin, 1992

Host: *Botaurus poiciloptilus* Wagler, Q, QM GL11394, specimens missing from QM, identification could not be confirmed.

45. ***Profilicollis sphaerocephalus*** (Bremser, 1811)

Syns: *Echinorhynchus sphaerocephalus* Bremser, 1811 in Rudolphi, 1819; *E. haematopodis* Rudolphi, 1819; *E. lari* Rudolphi, 1819 see Yamaguti, 1963

Filicollis sphaerocephalus Travassos, 1926; Golvan, 1960

Polymorphus sphaerocephalus Van Cleave, 1947; Webster, 1948; Schmidt & Kuntz, 1967; Amin, 1992

Parafilicollis sphaerocephalus Petrochenko, 1958

Falsificollis sphaerocephalus Yamaguti, 1963

Profilicollis sphaerocephalus Khoklova, 1974; Golvan, 1994: 17; Nickol, Crompton & Searle, 1999

Hosts: *Bizuria lobata* (Shaw), SA, AHC 2988

Haematopus fuliginosus Gould, SA, AHC 5047, 18036, 18050 CSIRO A59

Haematopus sp., AHC 42307-14

Larus novaehollandiae Stephens, SA, T, AHC 296, 1873, 3364, 3372, 18049, 18210, 42305, 42306

Larus pacificus Latham, SA, CSIRO A58

Pelicanus conspicillatus Temmink, SA, AHC 3386

Phalacrocorax melanoleucos (Vieillot), SA, AHC 2662.

Rhadinorhynchidae

46. ***Rhadinorhynchus johnstoni*** Golvan, 1969

Rhadinorhynchus pristis Johnston & Edmonds, 1947

Rhadinorhynchus johnstoni Golvan, 1969

Accidental host: dolphin, NSW, Johnston & Edmonds 1947: 17; AHC 19948.

Species inquirenda

No specimens or further reference corresponding to these records can now be found.

1. *Echinorhynchus* sp.

Krefft, 1871: 212; Johnston & Deland, 1929: 147

Host: *Delphinus forsteri* Gray; probably *D. delphis* Linn.

2. *Echinorhynchus* sp.

Johnston, 1912: 109; Johnston & Deland, 1929: 149

Host: *Eurystomus orientalis*

3. *Echinorhynchus* sp.

Johnston, 1910: 111; Johnston & Deland, 1929: 151

Host: *Phylidonyris novaehollandiae* (Latham) as *Meliornis novaehollandiae*

4. *Echinorhynchus* sp.

Johnston, 1910: 107; Cleland, 1922: 108

Host: *Psophodes olivaceus*

5. '*Echinorhynch*'

Cleland, 1922: 108

Host: *Myiagra inquieta* (Latham).

Acanthocephala

The following bird hosts are listed in Mawson et al 1986 as being infected with acanthocephalans but the material was listed as unidentifiable and has not been retained in any museum collection for further study.

Hosts: *Calidris ruficollis* (Pallas), *Coturnix ypsilophora* Bosc, *Egretta alba* Linn., *Entomyzon cyanotis* (Latham), *Falco longipennis* Swainson, *Hiraaetus morphnoides* Gould, *Hydroprogne caspia* (Pallas), *Macrorectes giganteus* Gmelin, *Oxyura australis* Gould, *Peltohyas australis* Gould, *Platalea regia* Gould, *Rallus philipensis* Linn., *Sterna nereis* (Gould), *Tringa terek* (Latham), *Vanellus tricolor* (Vieillot).

HOST–PARASITE LIST

MAMMALIA

Eutheria

Muridae

Hydromys chrysogaster
water rat
- *Corynosoma stanleyi*
- *Plagiorhynchus cylindraceus*
- *Porrorchis hydromuris*

R. fuscipes
bush rat
- *Moniliformis moniliformis*

R. norvegicus
brown rat
and as *E. rattus*
- *Moniliformis moniliformis*

Rattus rattus
black rat
and as *Epimys rattus*
- *Moniliformis moniliformis*

Rattus sp.
rat
- *Moniliformis moniliformis*

Suidae

Sus scofa
pig
- *Macranthorhynchus hirudinaceus*

Felidae

Felis catus
feral cat
- *Oncicola pomatostomi*
- *Porrorchis* sp.

Canidae

Canis lupus dingo
dingo
as *C. familiaris dingo*
- *Oncicola pomatostomi*

Vulpes vulpes
fox
- *Plagiorhynchus cylindraceus*

Otariidae

Arctocephalus forsteri
New Zealand fur seal
(in error as type host for *C. australe*)
- *Bolbosoma capitatum*
- *Corynosoma australe*

A. pusillus
Australian fur seal
and as *Gypsophoca dorifera*
- *Andracantha clavata*
- *Bolbosoma capitatum*
- *Bolbosoma vasculosum*
- *Corynosoma arctocephali*
- *Corynosoma australe*
- *Corynosoma cetaceum*

A. tropicalis
sub-Antarctic fur seal
- *Corynosoma australe*

Arctocephalus sp.
- *Corynosoma australe*

Neophoca cinerea
Australian sea lion
- *Corynosoma australe*

Phocarctos hookeri
New Zealand sea lion
- *Corynosoma australe*

Phocidea	
Hydruga leptonyx	*Corynosoma australe*
leopard seal	*Corynosoma bullosum*
	Corynosoma cetaceum
	Corynosoma pseudohammani
Leptonychotes weddellii	*Corynosoma cetaceam*
Weddell's seal	*Corynosoma pseudohammani*
Mirouga leonina	*Corynosoma bullosum*
southern sea elephant	
Ziphidae	
Mesoplodon bowdoini	*Bolbosoma vasculosum*
Andrew's beaked whale	
Mesoplodon layardii	*Corynosoma australe*
strap toothed beaked whale	
Balaenopteridae	
Balaenoptera auctostrata	*Bolbosoma balaenae*
minke whale	
Balaenoptera musculus	*Bolbosoma capitatum*
blue whale	*Bolbosoma turbinella*
Megaptera novaeanglae	*Bolbosoma balaenae*
humpbacked whale	
as 'whale' possibly *Megaptera nodosa*	*Bolbosoma balaenae*
Delphinidae	
Delphinus delphis	*Corynosoma cetaceum*
common dolphin	
as *Delphinus forsteri*	*Echinorhynchus* sp.
Rhadinorhynchus johnstoni	
Globiocephalas melas	*Bolbosoma balaenae*
long finned pilot whale	
as *Globiocephalas melaena*	
Globiocephala sp.	*Bolbosoma capitatum*
pilot whale	
Pseudorca crassidens	*Bolbosoma capitatum*
false killer whale	
Tursiops truncatus	*Corynosoma australe*
bottle nosed dolphin	*Corynosoma cetaceum*
Physeteridae	
Physeter catodon	*Bolbosoma capitatum*
sperm whale	

MARSUPIALIA

Dasyuridae	
Antechinus agilis	*Australiformis semoni*
agile antechinus	*Centrorhynchus bancrofti*
	Centrorhynchus sp.
	Plagiorhynchus cylindraceus
Antechinus stuartii	*Australiformis semoni*
brown antechinus	*Centrorhynchus bancrofti*
	Plagiorhynchus sp.
	Porrorchis hylae

Antechinus swansonii	*Centrorhynchus bancrofti*
dusky antechinus	*Centrorhynchus* sp.
Phascogale tapoatafa	*Australformis semoni*
brush-tailed phascogale	
as *Phascogale penicillata*	
but may be *Bettongia penicillata*	*Centrorhynchus* sp.
Sminthopsis leucopus	*Centrorhynchus* sp.
white-footed dunnart	*Plagiorhynchus cylindraceus*
	Plagiorhynchus sp.
Peramelidae	
Isoodon obesulus	*Australiformis semoni*
southern brown bandicoot	*Plagiorhynchus cylindraceus*
I. macrourus	*Australiformis semoni*
northern brown bandicoot	*Mediorhynchus* sp. larvae
	Plagiorhynchus cylindraceus
	Plagiorhynchus sp.
P. gunnii	*Australiformis semoni*
eastern barred bandicoot	*Plagiorhynchus cylindraceus*
Perameles nasuta	*Australiformis semoni*
long-nosed bandicoot	
bandicoot	*Australiformis semoni*
Potorodidae	
Potorous tridactylus	*Australiformis semoni*
long-nosed potoroo	*Plagiorhynchus cylindraceus*
Notorictidae	
Myrmecobius fasciatus	*Multisentis myrmecobius*
numbat	
Macropodidae	
Wallabia bicolour	*Plagiorhynchus cylindraceus*
swamp wallaby	

AVES

Spheniscidae	
Eudyptula minor	*Andracantha clavata*
little penguin	*Corynosoma australe*
Pygoscelis papua	*Corynosoma shakletoni*
gentoo penguin	
Phalacrocoracidae	
Leucocarbo atriceps	*Andracantha clavata*
blue eyed cormorant	*Corynosoma australe*
as *Phalacrocorax atriceps*	*Andracantha* sp.
Leucarbo colensoi	*Andracantha clavata*
as *Phalacrocorax colensoi*	
Auckland Island shag	
Leucarbo fuscescens	*Andracantha clavata*
black faced shag	
as *Phalacrocorax fuscescens*	
Phalacrocorax melanoleucos	*Andracantha clavata*
little pied cormorant	*Polymorphus biziurae*
	Profilicollis sphaerocephalus

Phalacrocorax sulcirostris	*Andracantha clavata*
little black cormorant	*Polymorphus biziurae*
as *P. microcarbo*	*Centrorhynchus* sp.
Phalacrocorax varius	*Andracantha clavata*
pied cormorant	
Phalacrocorax verrucosus	*Andracantha clavata.*
Kerguelen shag	
Phalacrocorax sp.	*Andracantha clavata*
Pelicanidae	
Pelicanus conspicillatus	*Polymorphus biziurae*
Australian pelican	*Profilicollis sphaerocephalus*
Procellaridae	
Pactyptila turtur	*Plagiorhynchus charadrii*
fairy prion	
Ardeidae	
Botaurus poicilopitus	*Polymorphus brevis*
Australasian bittern	
Nycticorax caledonicus	*Oncicola pomatostomi*
rufous night heron 'egret'	*Centrorhynchus* sp. A
Plataleidae	
Platalea flavipes	*Polymorphus biziurae*
yellow spoonbill	
Threskiornis molucca	*Polymorphus biziurae*
sacred ibis	
as *Threskiornis aethiopica*	*Plagiorhynchus cylindraceus*
Accipitidae	
Accipiter cirrocephalus	*Centrorhynchus asturinus*
collared sparrowhawk	
Accipiter fasciatus	*Centrorhynchus asturinus*
brown goshawk	
Accipiter novaehollandiae	*Centrorhynchus asturinus*
grey goshawk	
as *Astur novaehollandiae*	
and as *Astur cinereus*	
Aviceda subcristata	*Centrorhynchus asturinus*
Pacific baza	
as *Baza subcristata*	
Circius approximans	*Centrorhynchus asturinus*
swamp harrier	
hawk	*Centrorhynchus* sp.
Turnicidae	
Turnix castanota	*Oncicola pomatostomi*
chestnut backed button quail	
Turnix velox	Oncicola pomatostomi
little button quail	
Falconidae	
Falco berigoria	*Centrorhynchus asturinus*
brown falcon	

Falco cenchroides	*Centrorhynchus asturinus*
Australian kestrel	
Anatidae	
Biziura lobata	*Polymorphus biziurae*
musk duck	*Profilicollis sphaerocephalus*
Cygnus atratus	*Andracantha clavata*
black swan	*Polymorphus biziurae*
Megapodiidae	
Alectura lathami	*Mediorhynchus alecturae*
Australian brush turkey	
and as *Catheturus lathami*	
Rallidae	
Gallinula tenebrosa	*Plagiorhynchus cylindraceus*
dusky moorhen	
Pedionomidae	
Pedionomus torquatus	*Oncicola pomatostomi*
plains wanderer	
Haematopodidae	
Haematopus fuliginosus	*Plagiorhynchus charadrii*
sooty oystercatcher	
Haematopus longirostra	*Plagiorhynchus charadrii*
pied oystercatcher	*Profilicollis sphaerocephalus*
Haematopus sp.	*Profilicollis sphaerocephalus*
Glaeolidae	
Stiltia isabella	*Mediorhynchus* sp.
Australian pratincole	
Burhinidae	
Burhinus grallarius	*Porrorchis hylae*
bush thick-knee	
Charadriidae	
Chardris ruficapillus	*Plagiorhynchus charadrii*
red capped plover	
as *C. alexandrinus*	
Thinornis rubricollis	*Plagiorhynchus charadrii*
hooded plover	
as *Charadrius rubricollis*	
and *C. cuculatus* hooded dottrel	
Vanellus miles	*Plagiorhynchus cylindraceus*
masked lapwing	
Scolopacidae	
Limosa laponica	*Arythmorhynchus limosae*
bar-tailed godwit	
Numenius madagascarensis	*Arythmorhynchus johnstoni*
eastern curlew	
as *Numenius cyanopus*	

Laridae	
Larus dominicanus	*Corynosoma shakletoni*
kelp gull	
Larus novaehollandiae	*Polymorphus biziurae*
silver gull	*Profilicollis sphaerocephalus*
Larus pacificus	*Profilicollis sphaerocephalus*
Pacific gull	
gull	*Mediorhynchus* sp. B
Cuculidae	
Centropus phasianus	*Plagiorhynchus charadrii*
pheasant coucal	*Porrorchis hylae*
Strigidae	
Ninox boobook	*Centrorhynchus bancrofti*
southern boobook	
as *Ninox novaseelandia*	
Ninox strenua	*Centrorhynchus bancrofti*
powerful owl	
Podargidae	
Podargus strigoides	*Porrorchis hylae*
tawny frogmouth	
Alcedinidae	
Dacelo novaeguineae	*Centrorhynchus horridus*
laughing kookaburra	
Dacelo sp.	*Centrorhynchus horridus*
T. macleayii	*Centrorhynchus horridus*
forest kingfisher	
Todiramphus sanctus	*Centrorhynchus horridus*
sacred kingfisher	
kingfisher	*Centrorhynchus* sp.
Campephagidae	
Lalage leucomela	*Oncicola pomatostomi*
varied triller	
Menuridae	
Menura alberti	*Plagiorhynchus menurae*
Albert's lyrebird	
Menura novaehollandiae	*Plagiorhynchus menurae*
superb lyrebird	
Motacillidae	
Anthus novaeseelandiae	*Oncicola pomatostomi*
Richard's pipit	
Muspicidae	
Melanodryas cucullata	*Oncicola pomatostomi*
hooded robin	
Microeca leucophaea	*Oncicola pomatostomi*
jacky winter	
Turdus merula	*Oncicola pomatostomi*
European blackbird	*Plagiorhynchus charadrii*

Zoothera dauma	*Oncicola pomatostomi*
white thrush	
Zoothera lunulata	*Oncicola pomatostomi*
Bassian thrush	
as *Orecincla lunulata*	*Plagiorhynchus cylindraceus*

Pachycephalidae

Colluricincla harmonica	*Oncicola pomatostomi*
grey shrike thrush	*Mediorhynchus colluricinclae*
Oreoica gutturalis	*Oncicola pomatostomi*
crested bellbird	
Pachycephala inornata	*Oncicola pomatostomi*
Gilbert's whistler	
Pachycephala rufiventris	*Oncicola pomatostomi*
rufous whistler	
Rhipidura leucophrys	*Mediorhynchus colluricinclae*
willie wag tail	

Orthonychidae

Cinclosoma castonotus	*Oncicola pomatostomi*
chestnut quail thrush	
as *C. castaneum*	
Cinclosoma cinomomeum	*Oncicola pomatostomi*
cinnamon quail thrush	
Petroica goodenovii	*Oncicola pomatostomi*
red capped robin	
Psophodes olivaceus	*Plagiorhynchus* sp.
eastern whipbird	

Pomatostomatidae

Pomatostomus halli	*Oncicola pomatostomi*
Hall's babbler	
Pomatostomus ruficeps	*Oncicola pomatostomi*
chestnut crowned babbler	
Pomatostomus superciliosus	*Mediorhynchus coluricinclae*
white-browed babbler	*Oncicola pomatostomi*
Pomatostomus temporalis	*Oncicola pomatostomi*
grey crowned babbler	
and as *P. rubeculus*	

Sylviidae

Megalurus timorensis	*Plagiorhynchus cylindraceus*
tawny grassbird	

Plocidae

Poephila cincta	*Oncicola pomatostomi*
black throated finch	

Meliphagidae

Acanthagenys rufogularis	*Mediorhynchus* sp. B
spiny cheeked honeyeater	
Acanthochoera carunculata	*Oncicola pomatostomi*
red wattle bird	
Acanthochoera chrysoptera	*Mediorhynchus alecturae*
brush wattle bird	*Mediorhynchus colluricinclae*

Licheostomus plumulus	*Oncicola pomatostomi*
grey fronted honeyeater	
Licheostomus virescens	*Oncicola pomatostomi*
singing honeyeater	
Manorina flavigula	*Oncicola pomatostomi*
yellow throated miner	
Sturnidae	
Acridotheres tristis	*Plagiorhynchus cylindraceus*
common mynah	*Plagiorhynchus charadrii*
Sturnus vulgaris	*Plagiorhynchus cylindraceus*
common starling	
Paradisaedae	
Ptiloris victoriae	*Plagiorhynchus* sp.
Victoria's riflebird	
Maluridae	
Amytornis purnelli	*Oncicola pomatostomi*
dusky grasswren	
Malurus cyaneus	*Oncicola pomatostomi*
superb fairy wren	
Acanthizidae	
Acanthiza chrysorrhoa	*Oncicola pomatostomi*
yellow rumped thornbill	
Aphelocephala leucopis	*Oncicola pomatostomi*
southern white face	
and as *Climacteris leucopsis*	
Serricornis brunneus	*Oncicola pomatostomi*
red throat	
as *Pyrrhadaemus brunneus*	
Serricornis cautus	*Oncicola pomatostomi*
shy hylacola	
Serricornis fuliginosus	*Oncicola pomatostomi*
calamanthus	
Serricornis pyrrhopygius	*Oncicola pomatostomi*
chestnut rumped hyacola	
as *Hyacola pyrrhopygius*	
'hylacola'	*Oncicola pomatostomi*
Neosittidae	
Daphoenositta chrysoptera	*Oncicola pomatostomi*
varied sitella	
Climacteridae	
Climacteris affinis	*Oncicola pomatostomi*
white browed tree creeper	
C. melanura	*Oncicola pomatostomi*
black tailed tree creeper	
as *C. wellsi*	
C. picumnus	*Oncicola pomatostomi*
brown tree creeper	
Cormobates leucophaea	*Oncicola pomatostomi*
white throated tree creeper	
as *Climacteris leucophaea*	

Corcoracidae	
Corcorax melanoramphas white winged chough	*Mediorhynchus corcoracis*
Grallinidae	
Grallina cyanoleuca Australian magpie-lark	*Mediorhynchus robustus* *Mediorhynchus corcoracis* *Oncicola pomatostomi* *Plagiorhynchus cylindraceus*
Artamidae	
Artamus cinereus black faced wood swallow	*Oncicla pomatostomi*
Artamus superciliosus white browed wood swallow	*Oncicola pomatostomi*
Cractidae	
Gymnorhina tibicen Australian magpie	*Oncicola pomatostomi* *Plagiorhynchus cylindraceus*
Strepera versicolor grey currawong	*Oncicola pomatostomi*
Corvidae	
C. bennetti little crow	*Mediorhynchus corcoracis*
Corvus coronoides Australian raven	*Mediorhynchus corcoracis* *Plagiorhynchus cylindraceus*
C. mellori little raven	*Mediorhynchus corcoracis*
C. tasmanicus forest raven	*Mediorhynchus corcoracis*
Corvus sp.	*Mediorhynchus corcoracis*

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TWENTIETH-CENTURY ABORIGINAL HARVESTING PRACTICES IN THE RURAL LANDSCAPE OF THE LOWER MURRAY, SOUTH AUSTRALIA

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CLARKE, PA. 2003. Twentieth-century Aboriginal harvesting practices in the rural landscape of the Lower Murray, South Australia. *Records of the South Australian Museum* 36(1): 83–107.

Since European settlement, Aboriginal people living in rural areas of southern South Australia have had a unique relation to the landscape, reflecting both pre-European indigenous traditions and post-European historical influences. Aboriginal hunting, fishing and gathering practices in the twentieth century were not relics of a pre-European past, but were derived from cultural forces that have produced a modern indigenous identity. The Lower Murray ethnographic data presented in this cultural geography study were collected mainly during the 1980s, supplemented with historical information concerning earlier periods.

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Introduction

The Aboriginal people living in the Lower Murray region during the twentieth century were not hunters, fishers and gatherers in terms of their total subsistence economy; nevertheless, they continued some hunting, fishing and gathering practices. This paper explores contemporary relationships that indigenous people have with a landscape that has been transformed into an environment dominated by agricultural and urban activities. Unlike some northern desert and subtropical areas of Australia, where Aboriginal subsistence economies persist in an altered form in relative isolation (Altman 1987; Meehan 1982), European-style economic development in the south conflicts more directly with Aboriginal land use. In the Lower Murray, Aboriginal people have interacted extensively with Europeans since the 1830s. In spite of this, a distinct indigenous identity has remained and developed throughout this period (Clarke 1994, 1995, 1996a, 1996b, 1998b, 1999a, 2001a, 2001b, 2001ms). When Europeans first arrived in the Lower Murray region in the late 1830s, the Aboriginal people living there were differentiated into numerous descent groups and several dialects. Due to an early population crash and the eventual relocation of survivors into mission and state-controlled institutions in the late nineteenth century, the descendants formed a new cultural and social identity. Throughout the twentieth century, indigenous people with pre-European connections to the Lower Murray landscape have called themselves Ngarrindjeri.[1]

The pre-European hunter and gatherer subsistence economy in the Lower Murray region is, in comparison to the rest of southern Australia, well documented. Clarke (1985a, 1985b, 1986a, 1986b, 1987, 1988, 1998a) and Cleland (1957, 1966) have studied the ethnobotany of the region. Berndt and Berndt (1993), Campbell (1934, 1939, 1943), Campbell et al (1946), Clarke (1999b, 2001a, 2002), Hemming (1989, 1991), Hemming and Jones (1989) and Luebbers (1978) have provided overviews of the pre-European material culture. The main focus in the current work is with twentieth-century Aboriginal practices in the Lower Murray, although when Ngarrindjeri people are concerned data is included from the Riverland agricultural district of South Australia. The paper stems from the author's museum work and doctoral research addressing how indigenous people relate to a modern rural and urban landscape. It provides a list of words recorded from the local variety of Aboriginal English spoken during the author's field study in the 1980s. This adds to studies by Foster et al (1998,

[1] In early sources, such as Taplin (1859–79, 1874, 1879), Ngarrindjeri is written as 'Narrinyeri'.

2003) and Clarke (2001ms) that investigate the historical origins of twentieth-century Aboriginal English spoken in southern South Australia. Maps showing places of significance to Lower Murray people are provided elsewhere (Clarke 1994, 1999a, 1999b).

Historical Background

The Lower Murray cultural region covers that part of the Murray–Darling Basin south of the entrance of the Murray River into Lake Alexandrina, including the southern coast of Fleurieu Peninsula, the area surrounding Lake Albert and the Coorong. It formerly had a relatively high population density, with an estimated 6,000 people living there (Brown 1918: 230–231; Clarke 1994: 57–63) prior to the first smallpox epidemic of the 1830s. After official European settlement at Encounter Bay in 1836, the Aboriginal population continued to decline, chiefly due to other introduced diseases and land alienation (Clarke 1994: chapter 6; 1995: 156, end note 1; Gale 1969; Smith 1980). The survivors gradually moved into European-controlled situations, such as pastoral stations, the Point McLeay Aboriginal Mission and fringe camps

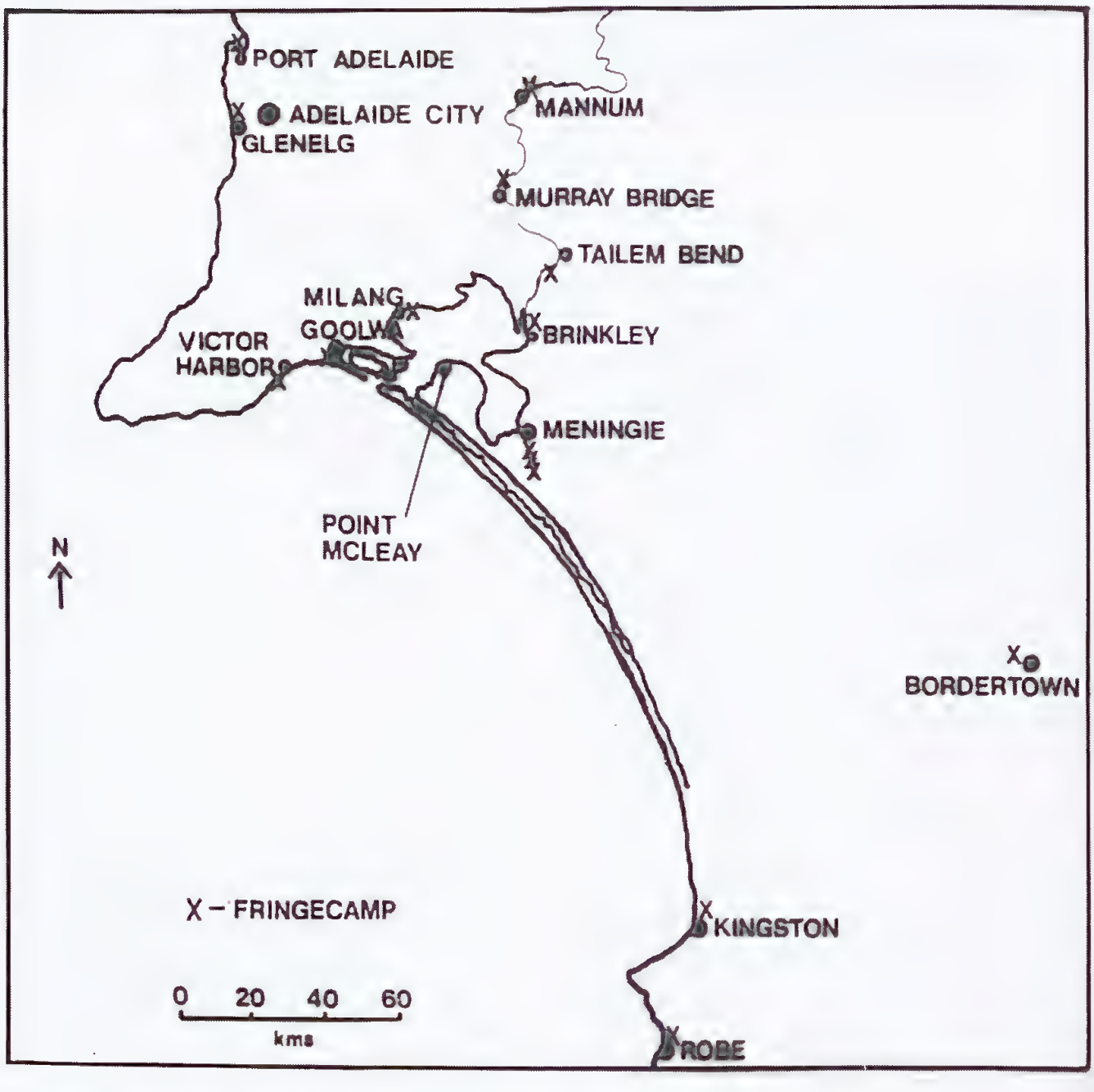

FIGURE 1. Twentieth century fringe campsites from Adelaide to the South East of South Australia.

around towns (Fig. 1).[2] Indigenous hunting, fishing and gathering activities declined as agricultural practices took over, commencing first in the northern section of the Lower Murray, restricting Aboriginal people to smaller parts of the landscape. Ngarrindjeri people worked in the whaling industry at Encounter Bay from 1836 (Clarke 2001a: 27–32). On the northern shore of Lake Alexandrina during the 1850s, Aboriginal people were drawn to living in towns, such as Milang and Wellington, due in part to their involvement in the fish trade (Taplin Journals, 12 April 1859). In 1859 the missionary George Taplin made plans to establish a fishing industry at Point McLeay, on the southern shore of Lake Alexandrina.[3] This appears primarily to have been intended to make the local Aboriginal community more sedentary. Additionally, local hunting, fishing and gathering activities at this time would also have served to supplement the mission's poor supplies of food, the result of a shortage of capital.

By the end of the nineteenth century, the physical environment of the Lower Murray had deteriorated. Irrigation schemes up river, which commenced in 1881 at Monteith and spread to Loxton, Berri and Renmark, and across the border into Victoria and New South Wales, kept water levels low (Fenner 1931: 84; Griffin & McCaskill 1986: 22; Williams 1969: 84, 243–244; 1974: 49, 235–236, 240). This increased the saltiness of the lakes and also decreased natural fish stocks. The sea water entering Lake Alexandrina in 1901, due to abnormally low river levels, destroyed the lucrative wool washing industry that had been established at Point McLeay in the early 1880s (Jenkin 1979: 177–178, 206). In 1905 the Aboriginal fishing industry started by George Taplin ended due to competition with white fishers who had the funds to obtain better technology (Jenkin 1979: 211). The barrages at Hindmarsh Island to prevent sea water entering Lake Alexandrina were completed in 1940 (Linn 1988: 181; McCourt & Mincham 1987: 11). The authorities in charge of the Point McLeay Aboriginal Mission at the time were in favour of their construction, as it promised them a more reliable supply of water suitable for agricultural purposes.[4] However, an unfortunate consequence was that the barrages contributed to the siltation of the Coorong Lagoon, which also had a decrease in freshwater flow from the south due to the South East drainage schemes (Griffin & McCaskill 1986: 22; Holmes & Waterhouse 1983: 49–50; Jack Koolmatrie cited Ely 1980).

The acquisition by the South Australian State Government of Narrung Station for subdivision into farming allotments occurred under the *Closer Settlement Act 1907* (Holtham, cited in Padman 1987: 10). The loss of this station as a whole was reported to be sorely felt by the Point McLeay people, who were previously allowed by the manager, George Hackett, to have free range over it for hunting, fishing and gathering (McCourt & Mincham 1987: 11). The Aborigines' Friends' Association, which administered Point McLeay from its base in Adelaide, responded to the planned subdivision by stating that 'it would be advisable to make the boundary between them [farmers] and the blacks as wide as possible'.[5] Due to growing problems that the Association had with managing the mission, particularly with its increasing resident population, the government took it under direct control in 1916 as a mission station (Jenkin 1979: chapter 9). The Lower Murray could no longer support Aboriginal people in a totally pre-European fashion, involving seasonal movements across a range of ecological zones. This region had become part of 'rural South Australia'.

The Modern Environment

The Lower Murray has seen much economic development since European settlement (Clarke 1994; Fenner 1931; Griffin & McCaskill 1986; Linn 1988; McCourt & Mincham 1987; Williams 1974), due to factors such as the favourable climate of the region, the potential of the river for

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[2] For instance, there were Aboriginal camps on Narrung and Poltaloch (pronounced by Aboriginal people as 'Portaluck') stations from the late nineteenth to early twentieth century. Aboriginal residents generally referred to the mission station as 'Raukkan' (or 'Ralkon'), which became an official settlement name in the early 1990s. Examples of fringe camps around towns were the Three Mile (from Tailem Bend) and One Mile (from Meningie).

[3] There are many entries in Taplin's Journals concerning the establishment of the fishing industry. The important references are 21 September 1859, 18 October 1859, 25 November 1859, 22 December 1859, 11 January 1860, 7 February 1860, 15 February 1860, 1 March 1860. See also Jenkin (1979: 97-98, 110-111).

[4] Memoranda to the Commissioner of Public Works from the Superintendent of Point McLeay and the Chief Protector of Aborigines (GRG 52/1, no.8/1930), State Records, Adelaide.

[5] *Register* newspaper, 7 December 1906.

transport and irrigation, and the close proximity to Adelaide and the sea. Major highways and railway lines pass through the Lower Murray, connecting South Australia to the eastern states. Crops and pasture have largely replaced the indigenous vegetation. Irrigation directly from the lake and river system is common practice. It is difficult for the contemporary observer to imagine how the region appeared before European settlement. Only in locations marginal to agricultural use, such as the Younghusband Peninsula, do large tracts of indigenous flora remain. Aboriginal reserves and national parks on both sides of the Coorong Lagoon contain most of what remains of the pre-European landscape.

Many of the pre-European plants and animals formerly found in the Lower Murray are now either scarce or locally extinct (Tyler et al 1983). Those organisms that formerly occurred in open woodlands, grasslands and the river have suffered most. Such habitats were not only the first ecological zones exploited by European settlers, but are also the areas most intensively transformed by agriculture. In contrast, plants and animals found in the mallee or heavily wooded areas have generally fared much better.

Europeans have introduced many foreign plant and animal species into the Lower Murray. Not all of these were essential for farming. To create a neo-European landscape, South Australian colonists also introduced organisms as pets and garden plants (Rix 1978: 1–7). Other species came accidentally as weeds and pests. European-style agriculture favours the economic exploitation of a few species. Therefore, the biological diversity of farming regions is generally far less than for uncultivated land in the same area. European colonisation has irreversibly changed the ecosystem of the Lower Murray.

European intrusion into the Lower Murray has affected the distribution and abundance of most indigenous animal species, primarily due to the clearance of pre-European vegetation, the alteration of the water flow conditions and the introduction of exotic fish species into the basin. For instance, during the author's fieldwork in the 1980s many middle-aged and older Aboriginal people lamented the reduction in numbers of favoured species of eating fish, such as silver perch (*Bidyanus bidyanus*), golden perch (*Plectrophilus ambiguus*) and Murray cod (*Maccullochella peeli*). The once abundant Murray lobster (*Euastacus armatus*) is also now scarce in South Australia (Reschke 1985: 173–174; Warneke 2000: 104, 226). Several species of water and ground birds became locally extinct (Eckert 2000b; Parker & Reid 1983). Mammals, in particular, have suffered immensely from European colonisation in the Lower Murray. For instance, the toolache wallaby (*Macropus greyii*), which featured in Lower Murray Aboriginal cosmology (Clarke 1997: 128), became extinct in the 1920s (Aitken 1983: 127; Robinson & Young 1983; Strahan 1983: 234).

The rural landscape of the Lower Murray created by Europeans provides refuge for many introduced species. A number of invertebrate pests have proliferated in the Lower Murray (Gross 1983; Zeidler 1983; Fisher 1983); for example, the introduced honey bee (*Apis mellifera*) is commonly encountered in all types of vegetation (Matthews 1976: 88), and has largely displaced indigenous bees, such as *Trigona* species, which were formerly a source of honey for southern Aboriginal people (Eyre 1845: 2: 273–274). Several foreign species of fish are established in the river and lake systems. In particular, the European carp (*Cyprinus carpio*), goldfish (*Carassius auratus*) and redfin perch (*Perca fluviatilis*) are replacing the pre-European fish fauna (Glover 1983; Sim et al 2000). Introduced birds, such as the house sparrow (*Passer domesticus*), feral pigeon (*Columba livia*) and starling (*Sturnus vulgaris*), predominate in the farm areas of the Lower Murray (Eckert 2000b). Foreign mammals, including the house mouse (*Mus musculus*), black rat (*Rattus rattus*), rabbit (*Oryctolagus cuniculus*), brown hare (*Lepus capensis*), feral cat (*Felis catus*) and fox (*Vulpes vulpes*), are living wild in the Lower Murray (Eckert 2000a). Domestic stock in the paddocks consists mainly of various breeds of cattle and sheep.

Some species of pre-European fauna have flourished under the altered ecological regime, whereas others persist in the reduced niches available to them. For instance, the stumpy-tailed lizard (*Tiliqua rugosa*) and the brown snake (*Pseudonaja textiles*) are favoured by the transformation of indigenous vegetation into pasture (Eckert 2000c: 92, 94; Thompson & Tyler 1983: 156). Field observations by the author during the 1980s suggest that species doing moderately well in certain areas are the echidna (*Tachyglosus aculeatus*) and water rat (*Hydromys chrysogastor*). Some animal species that became locally extinct in the Lower Lakes area have survived on the Younghusband Peninsula and in the Coorong National Park. These include the grey kangaroo (*Macropus fuliginosus*), brusher wallaby

(*Macropus rufogriseus*), emu (*Dromaius novaehollandiae*), wombat (*Vombatus ursinus*) and the mallee fowl (*Leipoa ocellata*). Wombats became locally extinct in the Lake Albert to Lake Alexandrina area by the late nineteenth century (McCourt & Mincham 1987: 10). Aboriginal sources in the 1980s claimed that the mallee fowl (native pheasant, *Leipoa ocellata*) disappeared in the Lower Lakes area during vegetation clearance in the early twentieth century.

The survival of these animals in the southern Coorong and parts of the adjacent South East of South Australia is the result of better coverage of pre-European vegetation. In the late twentieth century, some animal species spread back into the Lower Lakes area, presumably from surviving populations in the South East. For instance, grey kangaroos and emus reappeared on the Narrung Peninsula during the 1980s. Aiding this recovery was the existence of patches of indigenous mallee and sheoak scrub surviving on Aboriginal-leased land. Major causes of the loss of indigenous mammals were over-shooting and habitat destruction.

The plant species introduced by Europeans have had an irreversible effect on the Lower Murray landscape. In many areas weeds had reached equilibrium with the local vegetation by the 1980s. For example, the open areas on the sandhills of the Younghusband Peninsula were covered with the Mediterranean sea spurge (*Euphorbia paralias*) and marram grass (*Ammophila arenaria*), a dune-binding species from Europe.[6] The bridal creeper (*Myrsiphyllum asparagoides*), a garden plant originally from South Africa, had taken over pockets of remnant scrub in the inland regions of limestone karst. Weeds dominated the farmed areas, particularly around Point McLeay. Nuisance species for farmers included the boxthorn (*Lycium ferocissimum*)[7] from South Africa, evening primrose (*Oenothera stricta*)[8] from America and horehound (*Marrubium vulgare*)[9] from Europe, and many introduced grasses.

Rabbits have changed the structure of local flora throughout southern Australia (Walker 1985: 84-5). Richard Penney introduced rabbits on some of the islands in Encounter Bay in 1841 (Whitelock 1985: 65), followed by mainland introductions of the rabbit in the 1870s (Rolls 1984). This has undoubtedly made some plant species, formerly used by Aboriginal people as food and medicine, locally extinct or rare. Rabbits also may have caused the displacement of many species of small mammal. A demonstration of the environmental impact of rabbits occurred in the 1950s when, due to a crash in the rabbit population through myxomatosis, there was significant regrowth of vegetation on the sand dunes of Younghusband Peninsula for a short period (McCourt & Mincham 1987: 19). The whole of the Lower Murray has become modified into a European landscape.

Twentieth-Century Hunting And Gathering Practices

Although European settlement in the Lower Murray region occurred early by South Australian standards, some pre-European knowledge concerning the environment persisted in the Aboriginal community through the twentieth century. From the 1930s to the 1960s, researchers such as Harvey, Tindale and the Berndts recorded aspects of hunting, fishing and gathering practices from elderly people, such as Albert Karloan, Pinkie Mack and Clarence Long, who had maintained a 'memory culture' (Tonkinson 1993: xix).[10] By the late twentieth century there were still some people in the Ngarrindjeri community who knew the identity and method of use of particular species of plants and animals, as well as the associated Aboriginal words (see Table 1). For example, in the 1980s an elderly Ngarrindjeri man remembered the term *yulinthun*, which referred to the actions of a hunter who swam out into a lagoon underwater and pulled ducks under by their feet.[11] As stated elsewhere, fieldwork with the Aboriginal population in the 1980s produced

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[6] Alcock & Symon (1977) give lists of Coorong plant species. Plant origins are given by Jessop & Toelken (1986).

[7] Point McLeay Mission Station residents formerly ate the fruit (Wilson 1998: 42). In the 1980s some Aboriginal people would regularly shake boxthorn bushes growing in hedges, so that their fowls could eat the fallen fruits. Photographs (c. 1920) of boxthorn hedges are in the Ramsay-Smith collection, AA6, Anthropology Archives, S.A. Museum.

[8] Primroses dominated the Lower Murray landscape to the extent that one of the Narrung farming properties near Point McLeay was called 'Primrose Farm'. Mission children ate the seeds (Wilson 1998: 28).

[9] During the twentieth century Aboriginal people used horehound as a medicinal plant (Clarke 1987: 15).

[10] Clarke (2002: 149–150) provides an overview of these ethnographic sources.

[11] A related Ramindjeri word appears to be *yorl-un*, recorded as 'descending' or 'coming down' (Meyer 1843: 66).

TABLE 1. Fauna and flora terms used by Ngarrindjeri people in the 1980s

Species	Aboriginal term
Mammals	
cat (*Felis catus*)	*malgu*
dog (*Canis familiaris*)	*booba, ke:li*
echidna (*Tachyglossus aculeatus*)	*porcupine*
fox (*Vulpes vulpes*)	*kanatji*
horse (*Equus caballus*)	*porthi*
kangaroo, large (*Macropus* species)	*primpari, marlu, wangami*
mouse, house (*Mus musculus*)	*punthi*
possum (species?)	*punmathi*
rabbit (*Oryctolagus cuniculus*)	*bappa*
rat, water (*Hydromys chrysogaster*)	*ra:wlkandi*
sheep (*Ovis* species)	*tjambaki*
wombat, southern hairy-nosed (*Lasiorhinus latifrons*)	*watu*
Birds	
bird (all species)	*pulyeri*
chat, white-faced; tin-tack bird (*Ephthianura albifrons*)	*nankinduli*
coot, Eurasian (*Fulica atra*)	*thuri*
currawong, grey (*Strepera versicolor*)	*kilindi, kilinglin*
duck, black (*Anas superciliosa*)	*mookari*
duck, hardhead or white eyed (*Aythya australis*)	*pungkari*
duck, mountain (*Tadorna tadornoides*)	*mounties*
duck, musk (*Biziura lobata*)	*tilmarri*
emu (*Dromaius novaehollandiae*)	*pamu*
flycatcher, restless (*Myiagra inquieta*)	*tjeri-tjeri*
goose, Cape Barren (*Cereopsis novaehollandiae*)	*lawri*
gull, silver (*Larus novaehollandiae*)	*thrukeri*
hawk, brown (*Falco berigora*)	*kiraki*
hen, mallee (*Leipoa ocellata*)	*lawan*
heron, white-faced; crane, blue (*Ardea novaehollandiae*)	*krawli*
magpie, Australian (*Gymnorhina tibicen*)	*multhari*
mudlark; Murray magpie; piwi (*Grallina cyanoleuca*)	*thil-thil*
pelican (*Pelecanus conspicillatus*)	*nori*
plover, spur-winged (*Vanellus miles*)	*ratha-rathi*
raven (*Corvus* species)	*maragani*
shag, black; cormorant, black (*Phalacrocorax carbo*)	*yoldi*
skylark (*Alauda arvensis*)	*thilbadi*
snipe, little grey (species?)	*kripari*
stilt, banded (*Cladorhynchus leucocephalus*)	*nilkani*
swan, black (*Cygnus atratus*)	*kungarri*
tern, caspian (*Hydroprogne caspia*)	*tenetjeri*
wattlebird, red (*Anthochaera carunculata*)	*rungkan*
willie wagtail (*Rhipidura leucophrys*)	*ritjiruki*
wren, superb blue (*Malurus cyaneus*)	*watji(-bird)*
Reptiles	
dragon, bearded (*Pogona barbata*)	*gunap, wirrakothi*
bluetongue lizard (*Tiliqua scincoides*)	*pungkung*
skink, drop-tail (order Scincidae)	*kindi*
sleepy lizard; stump-tailed lizard (*Trachydosaurus rugosus*)	*galta, kalta, manthari*
snake (all species)	*krayi*
tadpole (all species)	*nyikunthi*
tortoise	*malanthaipèri*
tortoise, turtle (all species)	*thukabi*

Species	Aboriginal term
Fish	
bream, bony; pyberry fish; tukari fish (*Fluvialosa richardsoni*)	*thukeri*
callop; golden perch; yellowbelly (*Plectroplites ambiguus*)	*callop, pilalki, pilaki*
cod, Murray (*Maccullochella peeli*)	*ponde*
congolli fish (*Pseudaphritis urvilli*)	*kungali*
fish (all species)	*marmi*
mullet; yellow-eye (*Aldrichetta forsteri*)	*kanmeri*
mulloway; butterfish (*Argyrosomus hololepidotus*)	*malawi*
perch, silver; tcheri fish (*Bidyanus bidyanus*)	*tjeri*
porcupine fish (*Allomycterus pilatus*)	*danimudla*
tommy rough (*Arripis georgiana*)	*pukaratji*
Arthropods	
ant (all species)	*prildi*
flea (order Siphonaptera)	*titjeri*
lice, of the head (*Pediculus humanus*)	*gudlu, gudli, gooli, poti*
lice, of the pubic region (*Phthirius pubis*)	*mutharuk*
wood-grub (species?)	*waldaruk*
Plants	
apples, native; monterry (*Kunzea pomifera*)	*manthri*
ballart, coastal (*Exocarpos syrticolus*)	*doll's eyes*
box, white; Christmas-bush (*Bursaria spinosa*)	*palgi*
boxthorn (*Lycium ferocissimum*)	*katheri(-bush)*
bulrush; reedmace; flag (*Typha* species)	*makuru, manangkeri, manakeri*
cherry, wild (*Exocarpos syrticolus*)	*waltjeri (= wild cherry)*
cranberry, native (*Astroloma humifusum*)	*milbakorthi*
currant, native (*Leucopogon parviflorus*)	*kalathami, ngooli*
date, wild (*Billardiera scandens*)	*kundawi*
flax-lily, pale (*Dianella longifolia*)	*peentuk*
fruit, edible sheoak (*Casuarina stricta*)	*sheoak-apple*
grass, basket making (unidentified species)	*yalkeri*
grasstree (*Xanthorrhoea* species)	*kinyeri*
grasstree flower stem when dried (*Xanthorrhoea* species)	*ngleyi*
gum, from wattle (*Acacia pycnantha*)	*tangari*
honeysuckle (*Banksia ornata*)	*yelakut*
juniper tree (*Myoporum insulare*)	*boobialla, booalla, palberi*
lignum bush (*Muehlenbeckia cunninghamii*)	*watji(-bush)*
old man's beard (*Clematis* species)	*yalkuri*
pea, broom bitter (*Daviesia genistifolia*)	*kuranthantha*
pigface (*Carpobrotus rossi*)	*nganingi, poyup*
root, edible species of (unidentified species)	*mrangganyi, pakanu(-potato)*
samphire (family Chenopodiaceae)	*parragoni*
sedge, coastal sword (*Lepidosperma gladiatum*)	*ngrakani, thyuk, wingi*
sedge, hoary rapier (*Lepidosperma canescens*)	*pinki-moranyi*
sedge, spiny-headed (*Cyperus gymncaulos*)	*mangatu*
sedge, sticky sword (*Lepidosperma viscidum*)	*kukandu*
sedges used to make baskets & mats	*basket-rush*
sow-thistle (*Sonchus oleraceus*)	*thalgi*
wattle, coastal (*Acacia longifolia sophorae*)	*boobialla, booalla, kalari(-bush)*

information on the pre-European mode of subsistence not previously recorded (Clarke 1986b). Many Ngarrindjeri people still used Aboriginal terms for fish species in preference to European names.

During 1980s fieldwork by the author, Aboriginal people usually brought forth information about plant and animal uses within the context of narratives of their own life history. For instance, many of the Aboriginal people interviewed about bush resources recalled what they, as children, had observed being collected and used by older kinsmen many years ago. Some remembered the types of food, such as fruits and berries, they gathered and ate on the way to and from school. Detailed accounts of the environment were received from Aboriginal people who had formerly relied on natural resources to supplement their meagre family income. Such people trapped water rats for their skins, fished, and caught rabbits for food and for sale. A variety of methods were employed. For water rats and rabbits, Aboriginal hunters used steel traps and wire snares. Opportunistic harvesting occurred too. For instance, Jack Koolmatrie remembered that early in the twentieth century, Lower Murray people killed a beached 5.6 metre female whale near Rabbit Island in the Coorong Lagoon (Ely 1980). They dragged parts of it into their boat and later cut it up, distributing the meat among their neighbours at Point McLeay. On another occasion at Mypolonga, Koolmatrie recalled that his father killed a large Murray cod with a double-barrel shotgun blast because he had no spear at hand.

The nature of Aboriginal lifestyles in the Lower Murray preserved some pre-European knowledge of environmental resources. At Point McLeay local sources of wild food helped families who were on rations. Ngarrindjeri woman Dulcie Wilson recalled that in the 1940s and 1950s:

> Living by the lake, our diet consisted mainly of fish, bream, callup [golden perch], and cod. Rabbits also supplemented our diet. ... Sometimes, when father had shot a swan she [mother] would mince up the breast, mix it with herbs and onions and make delicious rissoles (Wilson 1998: 24).

From the time of the establishment of the Point McLeay Mission, Aboriginal family groups living there followed the practice of camping away from Point McLeay during the summer school break at places such as the Goolwa Channel, Ngalang (Gnurling Point), Mark Point and 'The Landing' near the Narrung Narrows.[12] All these summer camps were near inland waterways and were to some extent isolated from European settlements. It is likely that the earlier camps were formed around particular elderly family members who wanted to visit important cultural sites, such as seasonal camps and old burial grounds that were linked to their descent group. For Aboriginal people the camps served as a break from mission life, whilst for the mission authorities it probably eased the burden of providing food rations. Due to such seasonal movements, the Aboriginal population at Point McLeay during summer consisted mainly of the old and sick.

According to Lower Murray people interviewed in the 1980s, these annual trips continued until the mid 1960s.[13] The people used 'wurley-sticks' and hessian sacks to make shelters, and took sugar, tea, flour for damper, jam and blankets.[14] The main method of transport was by horse and buggy, although some people used dinghies too.[15] Wild food, such as berries, cockles, fish, emus, echidnas, rabbits and kangaroos supplemented their provisions once they arrived and a pelican or swan wing served as a brush to sweep the floor of the shelter (Wilson 1998: 40). Extended family groups would stay away from the mission station for several weeks. The summer trips by families reportedly had the official support of the Point McLeay authorities. The school did not require the children during that time and the coastal environment was pleasant for camping out during the summer.

The Coorong as a destination was particularly attractive for a number of reasons. Up until the Second World War, non-Aboriginal farmers had largely ignored the margin of the Coorong Lagoon with its shallow soils and lack of water suitable for irrigation. The Coorong has several declared Aboriginal reserves along its mainland shore, some of them with small houses and shacks. In

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[12] There are many early references to Coorong summer trips in Taplin's Journals (15 & 29 January 1862, 16 February 1862, 15 January 1863, 28 December 1864 – 3 January 1865).

[13] Hemming (1994: 14) provides a photograph of a summer camp along the Coorong, in about 1900. More recent references are DETE (2001b: 81, 98) and Wilson (1998: 39-40, 97).

[14] Temporary shelters made from bags were called *ngauwanthi*, shelter poles were called 'wurley-sticks', sugar was *pinyatawi* and tea was termed *lingali*. Elderly Ngarrindjeri people called damper *pampi*, although this term appears to be a Moandik word from the South East of South Australia (Clarke 2001ms).

[15] Buggies were referred to as *titjeri* (flea), a reference to the reliance of a buggy when being drawn upon the body of a horse (Clarke 2001ms).

the 1990s Lindsay Wilson, who was an elderly Aboriginal man with ties to the Coorong and South East of South Australia, stated that Jacob Harris had taken him and other youths from Point McLeay to the Younghusband Peninsula during the 1930s.[16] They took off all their clothes and lived by hunting, fishing and gathering. This was to 'introduce us to our country'.

In spite of the landscape changes by the early twentieth century, Aboriginal people in the Lower Murray retained a distinctly Aboriginal view and use of the physical environment, albeit in a modified form. Up until the 1930s some Aboriginal people, known in Aboriginal English as 'camp-blacks', lived in 'wurleys' (traditional shelters) on a hill overlooking the mission settlement. Some early traditional harvesting practices continued, particularly for people based in the fringe camps and living on reserves away from the mission. Some Ngarrindjeri people moved to other parts of South Australia to live and work. For example, the Giles family lived in the Riverland during the 1940s and 1950s by selling Murray cod when in season and water rat skins for the rest of the time. They lived in 'wurleys' made from introduced wild tobacco saplings and hessian bags, and by catching what food they could from around the camp:

> We ate ducks and swans, and their eggs, fish, caught yabbies now and then, and there were plenty of rabbits around, especially during flood time. We would just grab them out of the lignum bushes, where they sat trying to escape the rising water (Grace 1990: 159).

Some of this wild food was traded with local farmers for clothes, tobacco, flour and milk. Bellchambers (1931: 120) reported that in the 1920s at Swan Reach in the Riverland, descendants from the local Aboriginal groups lived in fishing camps but suffered 'certain hardships from having no fishing facilities reserved for them.' This seemed strange to him, considering that the camp was almost permanent.

Aboriginal people worked on the periphery of many small-scale industries. For example, Ngarrindjeri people remembered catching baby long-necked tortoises (*Chelodonia longicollis*) and parrots in the Riverland as youths in the 1950s for the Adelaide pet trade. Leeches were collected and sold for use by Europeans to treat various blood ailments (Clarke 1989: 3-4; Grace 1990: 171). Skinned and gutted rabbit carcases were sold to cray fishermen for use as bait (Wilson 1998: 118). Aboriginal people also boiled sheep heads and lamb tails for food and collected loose 'dead wool' from paddocks for sale (Abdulla 1993).[17] Short-term employment was gained from orchardists by fruit picking, from fishermen by cleaning fish, and from the farmers by stump and stone picking in the paddocks and hessian bag sewing (DETE 2001b: 59, 61, 69, 71). Non-Aboriginal people occasionally engaged in similar pursuits, but Aboriginal people living along the river relied on these activities to such as extent that it became a part of their rural lifestyle.

During more restrictive periods in the early twentieth century, such as when the 'colour bar' operated in the rural towns of the Lower Murray (Berndt & Berndt 1951; Clarke 1994: section 6.4), exclusion from many of the benefits gained through access to towns helped maintain a high level of interaction between Aboriginal people and the physical environment. In particular, it was apparent in the 1980s when interviewing Ngarrindjeri people that former dwellers of fringe camps had extensive knowledge of the medicines and edible plants that were 'used by the old people'. This was simply because they had needed these indigenous resources to survive. The proximity of their dwellings to main roads and settlements during the 1950s and 1960s did not lessen their connection with the broader environment. In the 1980s a few elderly people from this background still collected wild plants, such as sow thistle. The stems were eaten as food, described as 'blackfellow's salad', and the milky sap was used for treating cuts and warts (Clarke 1986a: 10; 1987: 9). Sow thistle was in a category referred to as 'blood medicine', because of its invigorating property as a food and tonic. When the 'colour bar' formally ceased to operate, allowing Aboriginal people much greater access to towns, the use of wild foods and building materials decreased markedly, since the wild resources of the landscape were no longer needed as a buffer between rations and wages. This had a detrimental impact upon the survival of Aboriginal knowledge of the pre-European uses of naturally occurring plants and animals.

The heavily regulated lifestyle of Aboriginal

[16] Also reported by Wilson (1998: 89, 115).

[17] Acrylic painting (S.A. Museum, A69498) by Ian Abdulla, 1990, features collecting dead wool in the Riverland agricultural district of South Australia.

people in the Lower Murray had helped to maintain some knowledge of traditional resource exploitation through hunting, fishing and gathering. Nevertheless, many of the former hunting and gathering places, particularly those in agricultural areas, were inaccessible to Ngarrindjeri people. By the mid 1960s, when legislation restricting Aboriginal movements was rescinded (McCorquodale 1987), visits by large family groups to summer camping sites, such as along the Coorong, declined in frequency. People now had other places they could go for recreation. The European-dominated landscape partially opened up for Aboriginal people, resulting in more movement into towns and the Adelaide suburbs. The summer trips, although recreational, had been important events that gave participants a sense of belonging to the Lower Murray landscape. Through the 1980s, the descendants of families that had lived on the Aboriginal reserves continued to maintain a connection with this area. Although based in Adelaide, some of them leased these reserves from the Aboriginal Lands Trust and maintained small holiday shacks on them.

In the 1980s older members of Aboriginal families that had taken up farming on various Lower Murray reserves generally had some knowledge about pre-European uses of plants and animals. This was so because of their earlier reliance on naturally occurring resources to supplement supplies gained from local towns and because they had an occupation that still involved use of the land. Fringe camp dwellers and Aboriginal farmers were marginal people in the sense that their greater remoteness from direct white control, in comparison to people 'on the mission', meant that they were unable to rely on outsiders for all their material requirements. These people therefore needed to be more opportunistic than those more directly supported by the state. Some Aboriginal people were able to move between the Aboriginal farms, the fringe camps and the mission station.

Fishing

Fishing was a major activity of Aboriginal people in the pre-European period (Clarke 2002), and continued after European settlement, with the involvement of Aboriginal people in the fishing industry. The seasonality of European-controlled fishing activities would have suited the incorporation of indigenous labour, particularly during the nineteenth century when Aboriginal movements were less restricted. European fishers in the Lower Murray adopted the use of many Aboriginal fish names. The importation of these words into Australian English, like those for other faunal species with a restricted distribution, was generally confined to the area of the source language (Ramson 1966: 120–121; Turner 1972: 123). For example, the golden perch is also widely known in Australian English, particularly in the eastern states, as 'yellow-belly', based on its appearance. In the South Australian section of the Murray River, contemporary anglers call it 'callop', which is probably derived from an Aboriginal term, *kalapko*, from the Ngaiawung and Nganguruku languages of the Riverland district (Clarke 2001ms). Nevertheless, many non-indigenous fishers of the Lower Lakes still refer to this species as *tarki*, based on one of the associated Ngarrindjeri words (Clarke 2001ms; Eckert & Robinson 1990: 18–19; Smith 1930: 229; Turner 1972: 123). During the author's 1980s fieldwork, Lower Murray people exclusively used another Ngarrindjeri word, *pilalki*, for this fish.

In the 1860s involvement in the Lower Lakes fish trade centred at Milang was a major part of the economy of the Point McLeay Aboriginal Mission. The creation of the Murray River Barrages, completed in 1940, destroyed this mission station enterprise (Clarke 1994: section 6.1). In particular, the mulloway (*Argyrosomus hololepidotus*) and jumping mullet (*Liza argentea*) fisheries around the Murray Mouth and in the Coorong suffered (Olsen 1991: 2, 21–22; Sim et al 2000: 103, 105). Ngarrindjeri people also participated in the Murray River fishing industry (Abdulla 1993; Grace 1990). Oscar Kartinyeri recalled during an interview with the author in 1988 that Aboriginal people in the Lower Murray and upstream to the Riverland agricultural district of South Australia in the early twentieth century used handmade nets to catch fish. These nets were made from split rushes, scalded before knotting to strengthen them. The fish would be driven up creeks leading into the river and the net placed across the entrance. Fish were then forced back downstream into the net. Golden perch and silver perch were often caught in this manner. Apparently the Mannum to Renmark area of the Murray River had many such creeks suitable for this purpose. According to Jack Koolmatrie, nets and fish-traps were still being utilised by Aboriginal people in the Coorong during the same period (Ely 1980). Bellchambers (1931: 21–22) claimed that along the Murray

River the Aboriginal fishing spear made from two lengths of fencing wire mounted on a wooden shaft was still commonly made in the 1880s and was the last pre-European style weapon to disappear from general use. The poorer examples he saw being made in the 1920s were for sale to European 'relic hunters'.

During the author's fieldwork, an Aboriginal person gave an account of how Aboriginal people living along the Murray River during the 1950s stored surpluses of fish. A Ngarrindjeri man and his family travelled to the Riverland to find seasonal work, such as fruit picking. Fish from the river, caught by the father, were a major source of food. The man was eventually offered a shearing job away from camp for a few days. Nevertheless, he did not want to leave his family without a means of getting food. Therefore, before leaving he fished, catching seven or eight fish for several meals. The surplus was kept in a nearby small muddy pond. The fish remained alive for several days, and were pulled out by his family as required. This man apparently often put fish there. This method of preserving food is similar to that for the fish storage ponds described in the early ethnographic literature (Clarke 2002). Near Pelican Point, European fishers also kept their fish alive by placing them in 'pounds' made of ti-tree stakes, while they waited for favourable weather to allow transportation to the Goolwa market (Evans 1991: 40). It is not known who learned this practice from whom.

Aboriginal people were opportunistic in some of their economic activities. For instance, from August to September a large number of bony bream (*Nematalosa erebi*) die of natural causes in Lake Alexandrina and Lake Albert, floating to the surface. Local Aboriginal people were once in the habit of going to the lakeshore or heading out in small boats to collect them. According to Ngarrindjeri sources, up until the 1930s and 1940s old women at the mission station would organise children into groups with hessian bags to collect the dying fish from the lake shore. The only fish taken were those with red gills, as this is a sign of their freshness. This species of fish has sweet flesh, although its numerous bones make it commercially less valuable.[18] Many younger Aboriginal people refused to eat this fish, and still do, precisely because it is so bony. In the 1980s a few of the older Lower Murray people were still able to cook the fish in such a way that the bones came away in one piece.

As a result of a decline in the Lower Lakes fishery, by the 1980s there were few Aboriginal people living at Point McLeay or in other Lower Murray towns who had any direct experience with commercial fishing. Whereas many older Aboriginal people could remember a time when favourite indigenous fish were abundant, by this time mainly European carp was caught. A few of the local non-Aboriginal people with fishing licences caught mainly estuarine fish, such as yellow-eye mullet (*Aldrichetta forsteri*) in the Coorong, and European carp (*Cyprinus carpio*), redfin perch and some golden perch in the Lower Lakes (Olsen 1990; Sim et al 2000). Aboriginal people who were middle aged or older, particularly women, were the main recreational fishers at Point McLeay. During fieldwork it was observed that several elderly women living there enjoyed fishing for silver perch and golden perch. A favourite location for them was at 'The Bulrushes', near Wangarawar Point on the northeastern edge of Point McLeay town reserve. Groups of old women, no longer burdened by child rearing, were in the habit of going fishing for long hours on the lake shore. Carp was the main fish species caught, but was generally left to die on the bank. Only a few of the Point McLeay residents would eat such coarse meat. Aboriginal people sometimes used it as yabbie bait (DETE 1998: 105). Parents and grandparents would occasionally take their younger children fishing along the lake or river. Youths also went fishing in the lagoons for carp with handmade thrusting spears.

During the author's Lower Murray fieldwork in the 1980s, most of the fishing by Aboriginal people was with hand-lines. Throughout southern South Australia, Aboriginal people often stated that they were reluctant to fish with rods. This is probably, to some extent, due to the inconvenience of carrying so much tackle.[19] It was also said that the use of a fishing rod was 'too flash'. The hand-line tradition of fishing was an expression of the modern southern Aboriginal identity. Earlier in the twentieth century, Ngarrindjeri fishers often made their own lines from cord, with sinkers made from lead melted in

[18] A version of the Ngurunderi story, told in schools, explains how this fish became bony (Education Department of South Australia 1988). In the Ngurunderi mythology, bony bream is the fish that young women are forbidden to eat (Berndt 1940: 173).

[19] Aboriginal people in southern Australia, before the arrival of Europeans, probably did not commonly use the fishhook and line (Clarke 2002: 150–151).

a teaspoon (DETE 2001b: 82, 88). So strong was the hand-line practice in the 1980s that Aboriginal people consciously drew this distinction between themselves and white fishers. A young Aboriginal man explained that 'Only whitefellas use rods. Nungas [Aboriginal people] do it blackfella way.'[20]

Shellfish Gathering

Lower Murray people formerly collected shellfish in great numbers (Cann et al 1991; Luebbers 1978, 1981, 1982; Pretty et al 1983: 117–118; Tindale 1930-52: 67). The middens of mollusc shells frequently found along undisturbed sections of banks of the river and lakes, and on the shores of the Coorong and sea, provide evidence of this. Some Aboriginal people were employed by Europeans to collect cockles (pipi, *Plebidonax deltoides*) from along the Coorong beach in sugar bags (DETE 2001b: 88). By the late twentieth century, Aboriginal people largely ignored mussels (such as *Velesunio ambiguus*) and cockles as a food source, possibly due to environmental changes in the Lower Lakes making them either scarce or not as easily gathered. Up until the 1960s, when Aboriginal families visited Younghusband Peninsula and the Goolwa area during the summer, cockles and periwinkles were eaten (DETE 2001b: 64, 69, 70, 98). By the 1980s Lower Murray people rarely went there, apart from infrequent day visits. In spite of the proximity of Point McLeay to the sea, the modern landscape made it difficult for Aboriginal people to get to the ocean. Few Aboriginal people in the Lower Murray had access to watercraft or to the off-road vehicles needed to get to the beach via the Forty Two Mile and Ti-Tree Crossings. The contrast between the riverine and marine zones was made more apparent after the construction of the Murray Mouth Barrages, completed in 1940 (McCourt & Mincham 1987: 11).

During the 1930s and 1940s yabbies ('crawfish', *Cherax destructor*) were caught by Ngarrindjeri people in a small bay near Wangarawar, east of Point McLeay. There were two methods employed to catch yabbies: pumping their mud holes with one's foot, which forced the occupant out of a connecting tunnel; or fishing for them with meat on a string (Wilson 1998: 92). Ngarrindjeri woman Jenny Grace recalled that as a child in the Riverland during the 1950s:

> We'd be in the water a lot getting yabbies too. In the winter time we used to go and crawl in the swamp for yabbies. We'd feel under the blanket weed and we'd find them under there (Grace 1990: 166).

Yabbies were important, not just as food but also as bait for Murray cod fishing (Abdulla 1993). In the 1980s Lower Murray people caught yabbies, chiefly during visits to the Riverland, by using nets and wire traps.

Mammal Hunting

By the early twentieth century, most of the traditional material culture and skills associated with Aboriginal hunting and fishing practices in southern South Australia had disappeared (Hemming 1991: 134; Sutton et al 1988: 186). Duck nets and spears had previously typified hunting and fishing in this region (Clarke 1994: section 4.2; Hemming & Jones 1989). In the case of Lower Murray clubs, a few types persisted. Men kept the fighting stick, or *kanarki*, as a weapon of defence in their wurleys and houses (Wilson 1998: 110). This was the custom as late as the 1940s, according to Aboriginal sources. Also, until about the 1960s, male youths were in the habit of using a short club, or *wadi* (waddy), with a single or double bulbous head to throw at rabbits (DETE 2001b: 82, 89; Wilson 1998: 39, 58). For them, the killing of rabbits was a game of skill, the thrower having to gauge the distance whilst aiming at the head. With the demise of wurley camps and the introduction of firearm restrictions, these 'old' style weapons have become souvenirs or museum pieces.

In the 1980s Ngarrindjeri people hunted rabbits and birds by shotgun or .22 rifle, chiefly as a recreational activity for the warmer months of the year. Lower Murray people could remember eating other creatures such as wood grubs, snakes, echidnas and a variety of lizards. Kangaroos were eaten less than introduced red meat sources like sheep, mainly due to their scarcity. In the decades prior to the 1980s, most kangaroo meat came from areas in the South East of South Australia, such as Coonalpyn or Kingston, where they were still

[20] Aboriginal people define Nungas (pronounced 'Namgars') as indigenous people from southern South Australian communities (Clarke 2001ms; Mattingley & Hampton 1988).

relatively common. Aboriginal men had earlier been involved in shooting kangaroos for their hides in the South East (Wilson 1998: 96). During the 1980s at Point McLeay, some people, originally from the West Coast of South Australia, would catch, cook and eat blue-tongue and sleepy lizards, which are relatively common on the Narrung Peninsula.

Ngarrindjeri family groups hunted water rats for their skins, which were sold to European furriers. During the early to mid twentieth century this appears to have been more commonly practised along the Murray River, from Tailem Bend to the Riverland. Ngarrindjeri woman Jenny Grace remembered how water rat hunting was a common activity during her childhood in the Nildottie area of the Murray River during the 1950s. On the family boat:

> Most of the room would have been taken up with the boards, and I would have to sit on top of them. These boards were used for pegging out rat skins. ... We'd just travel around, maybe row about seven miles, camp near where there was a big swamp or something, where we thought it was going to be good for rats. I think dad had about 120 traps and they would have been the most valuable possessions that we had. ... We'd stay in one place for about three days usually, until the skins dried, and if we ran out of boards to peg them on we'd peg them onto the gumtrees then roll them up ready to be sold (Grace 1990: 158).

The skins were destined for the fur market in Adelaide. The families of Bluey Roberts and Jerry Mason junior were also involved in catching water rats in the Riverland (DETE 1998: 86; 2001b: 78). Colin Cook said that at one time they sold the water rat skins for about four shillings each (DETE 2001b: 62). Ian Abdulla, who lived at Cobdogla during the 1950s and 1960s, claimed that:

> There was another way of making an income and that was catching rats and selling the skins to a buyer at Renmark in the Riverland so the skins could be used to make purses or handbags. To get the rats we had to dive down to the bottom of the creek or swamps to get mussels to put on the traps. ... We set the traps on logs to catch the rats overnight. ... The next morning my father and brother would go out in the boat to check the traps to see how many rats we caught overnight, then they would take the rats home to be skunt or skinned. Then the skins were pegged out on the boards and put in the sun to dry (Abdulla 1993).[21]

In the 1980s Ngarrindjeri woman Laura Kartinyeri said that her family had been heavily involved in the water rat skin trade, particularly when they were based in the Three Mile Camp at Tailem Bend. Such activities fitted in with spells working as farm labourers or in local factories.

During the author's fieldwork, rabbits were the most readily obtained wild mammals in the Point McLeay region. Although most Aboriginal people knew that the rabbit was an introduced species, this did not diminish the cultural importance of rabbit shooting. On many occasions hunting parties were organised spontaneously, rather than in advance. A visitor who was unfamiliar with the region may have had one of these events arranged for their benefit. This allowed the Lower Murray people at Point McLeay to 'show our land' to the newcomer. Even when a hunting party was primarily a response to a desire for rabbit or duck meat, the cultural significance remained. A senior person in the community made arrangements for obtaining guns and a car. The type of car preferred was usually a large sedan with high clearance from the ground. Generally, the time chosen to go 'rabbiting' was the early evening when it was becoming dark. Hunting excursions were generally to nearby Aboriginal-run land reserves and farms, such as Block K, Gum Park, or in the paddocks at the back of Big Hill.

Local hunting trips were almost entirely male events. Women might be present when the shooting was secondary to another activity, such as getting firewood. On most trips experienced by the author, a particular old 'uncle' at Raukkan was consulted early during the arrangements. This was to see if he would come along, or whether he could lend some of his guns, or simply to tell him that people were 'going bush'. The driver was usually the organiser, because he took control of where the party went. The favoured areas for shooting had driving hazards which were difficult to see at night. Obstacles to avoid included fallen trees, tree stumps, low patches of scrub, sand drifts, rabbit warrens, piles of limestone, soakages, rusting farm machinery, barbed wire tangles and general rubbish. It was therefore necessary for the driver to have a high degree of localised geographic knowledge. Men who had worked on the Point McLeay properties took pride in identifying the landscape during the night's

[21] See Abdulla (1993), Clarke (2001b, pl. 92) and Hemming & Clarke (1991: 14) for paintings of water rat hunting activities.

activities and were delighted when outsiders lost their sense of direction. Although the driver usually did little shooting, the structure of the event meant that his was a high prestige role. Youths who took part generally either spotted with the searchlight or acted as runners to collect and finish off the shot rabbits.

There was some resistance to shooting at animals other than rabbits, despite the fact that hares, foxes, a small number of kangaroos and deer were often seen.[22] The stated reason was usually that they were either not common or simply that they were not 'doing the hunters any harm'. In this context, Aboriginal people articulated that feral animals were to some extent like them, which is outside 'white law'. The shooting parties of local non-indigenous farmers do not possess this sentiment. Although they engage in rabbit shooting for recreation, the structure of their activity generally reflects their personal economic interests in getting rid of pests.[23]

For Aboriginal people the aim was to shoot rabbits through the head, as this was a discarded part of the carcass. A plastic garbage bag in the boot of the car held the shot rabbits until the conclusion of the shoot. The gutting took place in the field in front of the car's headlights, as this was a messy job. The removal of the entrails made this operation too dirty for home. Back at Point McLeay, the heads and lower legs of the rabbits were chopped off, using a hatchet or machete on a block of wood. On a good night there would be as many as 50 rabbits to skin and gut. If there were a large number of rabbits killed, the processed carcasses were held by the hide of their legs on a clothesline until the whole job was over. This prevented dogs from running off with them before the end of the job. Hungry dogs at the settlement quickly removed the refuse produced.

The rabbit meat was ready for cooking after it had been soaked overnight in water to remove some of the strong odour of the flesh peculiar to rabbits. Next morning, various senior people at Point McLeay received the carcasses that were wrapped first in layers of newspaper and finally plastic. Often, the biggest share went to the provider of the guns or ammunition, or to the owner of the vehicle. Although people in the Point McLeay settlement would often hear about a hunting trip the next day, the specific details were generally not discussed outside the local Aboriginal group. Hunting on Aboriginal land occurred in an Aboriginal realm of activity that Point McLeay people preferred to keep to themselves.

Bird Shooting

The main species of duck hunted by Point McLeay people in the late twentieth century were the grey teal (*Anas gibberifrons*) and the mountain duck (*Tadorna tadornoides*). According to Aboriginal sources, the hardhead duck (*Aythya australis*) was common in the Lower Lakes but seldom seen by the 1980s (Wilson 1998: 90). Other species formerly hunted for food by mission station residents include the banded stilt (*Cladorhynchus leucocephalus*), black swan (*Cygnus atratus*) and Cape Barren goose (*Cereopsis novaehollandiae*). In particular, cooked swan intestines were regarded as a great delicacy[24] and the Cape Barren goose was desired for Christmas roast. The pelican (*Pelecanus conspicillatus*) was often hunted for its feathers, which were used in making house ornaments (Clarke 1994: 290, 336; 1996a: 75; DETE 2001b: 70). The flesh of the pelican was said to be like the shag (*Leucocarbo fuscescens*), considered 'too fishy to eat' by most Aboriginal people in the Lower Murray during the 1980s. Nevertheless, a Ngarrindjeri man claimed that the breast of the pelican was like steak if properly prepared. The carcass needed hanging for a few days 'to get rid of the wild taste'. Bait for fishing sometimes came from the flesh of the silver gull (*Larus novaehollandiae*). The bird was caught by baited hook on nylon fishing line tied to a log or branch.

Duck shooting usually happened in the early morning. It involved more stealth than for rabbits; the shooters often crawled for some distance and then hid. For this reason, bird-shooting groups from Point McLeay were generally smaller than those for rabbits. After travelling to the area in a car, the hunters walked to the lagoon. Talking outside the vehicle was minimal and in whispers. Messages were by hand signals and single word utterances in Ngarrindjeri language, such as *nakan*

[22] The deer originally escaped in the 1980s from a stud near Narrung. The stud was then closed and the remaining stock removed.

[23] Morton (1990) has investigated the cultural role of non-Aboriginal hunting in contemporary Australia.

[24] Swan intestines were called *kungari waltjeri*.

('look'), *kungen* ('listen'), *tawul* ('stop') and *lewin* ('lie down'). As for rabbit shooting, knowledge of the landscape was crucial for duck shooting, not just to avoid obstacles but also to find a suitable place from which to shoot.

The main duck hunting sites near Point McLeay were the lagoons at 'The Bulrushes' and on the flats behind 'Big Hill' near Teringie. At the latter site the lagoons were periodically flooded. Point McLeay workers deliberately opened up the entrance to the lake with a tractor to produce a habitat to attract water birds. Bunkers were dug out of the mud well in advance of the hunting trip and the walls were covered with samphires (*Halosarcia* species). These served as shooting points next to lagoons, and were particularly necessary near Teringie where the landscape is open. Another spot at the Teringie lagoons from which to shoot was next to some large boxthorns. This area was '*prildi* place' to some – a reference to the numerous ants found there at night. By crouching in front of the bushes, a shooter wearing dark clothing remained hidden from the birds. At 'The Bulrushes' there were plenty of hiding places among the lignum (*Muehlenbeckia cunninghamii*) and bulrushes (*Typha* species). The remains of an old limestone-walled bunker on the more open side of 'The Bulrushes' lagoon were still visible during the 1980s.

From a good early morning hunt, a dozen ducks might be shot. Birds were plucked on site before returning home to avoid making a mess in the township. Also, feathers lying about a person's yard may lead to unwanted questions from visitors from outside their extended community. There was some distrust of the authorities interfering with their activities. Back at Point McLeay, as with rabbits, senior people in the community tended to be given most of the catch.

Collecting Bird Eggs

The practice of collecting swan eggs, known in Aboriginal English as 'swan-egging', was a major activity for Aboriginal people in the Lower Lakes and Murray River districts up until the late twentieth century (Abdulla 1993; DETE 2001b: 69; Ely 1980). Swan eggs (*kungari ngatjeri*) are large and greenish white; they are equivalent in volume to five average fowl eggs. Although they taste much the same as fowl eggs, those of the swan are richer. The eating of a whole egg by a single person has been known to cause diarrhoea.

The persistence of bird egg collecting as a seasonal activity had continuity with pre-European harvesting practices. Aboriginal informants described how they would carefully observe swan behaviour from late winter. Although the swan-breeding season is broad and variable, Aboriginal people claimed that in the Lower Murray it occurred when the water levels in the lagoons were high. The men first tried to determine the general area where floating nests made from reeds were being built. To find the exact location, the collectors searched for swan tracks pushed through the bulrush beds. Collectors generally obtained the eggs by wading out into the lagoons, although occasionally small boats were used. Putting eggs in water tested their freshness – the ones that sank were considered good for eating. A few older Lower Murray people preferred to cook and eat eggs that had 'turned', meaning that they had chicks in them about to hatch. Swan-egging occurred mainly in spring, before tiger snakes (*Notechis ater*) become a major hazard in the warmer months.

Aboriginal people travelled long distances to obtain swan eggs. In the early twentieth century, men from the Point McLeay Mission Station used blanket sails on their dinghies to travel across the lake to Point Sturt, returning with hundreds of swan eggs (Wilson 1998: 44). As late as the 1950s, two women from Point McLeay rowed across Lake Alexandrina to Mulgundawa to obtain swan eggs in early spring (Padman 1987: 24). They returned with their dinghy so heavily laden with swan eggs that it was reported that only about 75 millimetres of the boat was above water. Certain Europeans in the Narrung area reportedly received some of the booty as a gift. Other Ngarrindjeri people used to row up Currency Creek in the southern Fleurieu Peninsula to collect swan eggs (DETE 2001b: 87).

European naturalists did not look favourably upon the taking of swan eggs. Inspector McIntosh of the Fisheries Department, before the First World War, recorded that at Tanunda Bay along the Coorong 'two half-castes had arrived with a boatload of swans' eggs, which system of wholesale robbery in the closed season the inspector understands is a common practice around the lakes'.[25] The ornithologist Captain SA White recorded his views in his account of a bird

[25] *Register* newspaper, 2 November [year not recorded] (Cutting Book, Anthropology Archives, S.A. Museum).

watching party he led to Dodd Creek on the western side of Lake Albert. He reports:

> We intended to continue our observations among the water birds here, but to our disgust, we found a party of natives encamped. They trade under the name of aborigine, but most of them have very fair skins - in fact, quite white, as I remarked before. These men destroy a fearful number of swans, by rifling the nests. This outrageous slaughter should be stopped (White 1913: 57).

The scientific concerns of White and his colleagues were not compatible with the needs of local Aboriginal people.

Aboriginal people had to collect swan eggs by stealth. A farmer living near the Point McLeay settlement provided one account of a swan expedition from Point McLeay. She said:

> Only a few years ago, the alarm was sounded all along the lake edge that four 'boys' from Point McLeay were missing. They had gambled that they could get some swan eggs although they knew that it was illegal. Those of us who lived along the waterway switched on lights in case the missing boys needed land marks. Some of the men were in the act of rigging up spotlights on four wheel drive vehicles when the call came that they were safe. Actually they'd been sitting behind some reeds for some considerable time, afraid to land, as they could see a police patrol vehicle at the ferry. Eventually they threw their forty odd eggs overboard, wrongly thinking that the officer was waiting to catch them (Padman 1987, p.25).

Since the 1980s Aboriginal people were legally able to remove the eggs in a restricted number of places, as long as it was not part of a commercial venture (Wilson et al 1992: 91-2). Nevertheless, as with rabbit and duck hunting, they tended to keep secret the details of these activities.

During the 1980s Lower Murray people generally ignored the eggs of birds other than the swan. Nevertheless, Ngarrindjeri informants say that in the 1940s and 1950s eggs of the silver gull were often obtained for eating. Collecting took place from islands in the Coorong. In particular, people living on nearby Aboriginal reserves on the mainland side had access to these resources. Other species whose eggs were eaten include the coot (*Fulica atra*), water hen (*Porphyrio porphyrio*), teal (*Anas gracilis*) and black duck (*Anas superciliosa*) (DETE 2001b: 62, 64, 78–79, 94). Aboriginal people in South Australia had the right to take wildfowl eggs until this right was repealed under the *National Parks and Wildlife Act 1972*.[26] Under the *Fauna Conservation Act 1964* that it replaced, Aboriginal people had the right to hunt out of season, on crown land and on private property. In the latter case, hunting was allowed only if the landowner gave permission. In the 1972 Act no consideration was given to Aboriginal land use. Most Ngarrindjeri people spoken to in the 1980s asserted that they had the moral and cultural right to take a few swan eggs, as long as at least one egg per nest was left untouched. Aboriginal people claimed that swans would generally only rear one chick, and they therefore thought it was reasonable to leave only a single egg to become an adult. In the Lower Murray region Aboriginal gatherers stated that there are generally four eggs in each clutch.[27]

Artefact Manufacture And Art

Aboriginal people in the Lower Murray during the 1980s considered that the knowledge of how to make 'old time' artefacts, and of where in the landscape to obtain the necessary raw materials, helped to reinforce their Ngarrindjeri identity. After a long period, when Aboriginal woodcarving and art practices had largely vanished from the Lower Murray, these traditions were revived in the early 1980s. Some artefacts, described as 'old time' examples, were made for Aboriginal use as home decorations (Clarke 1996a). Some were also sold to non-Aboriginal collectors and museums. In these cases the objects were essentially statements of the artists' connections with the pre-European past. Artefacts such as baskets and mats were utility articles in the pre-European period, but from the 1980s they had the added status of icons, particularly for local Aboriginal people.[28] The interest in and consumption of Aboriginal culture by such non-Aboriginal agencies as contemporary art and artefact collectors, museums (Hemming & Jones 1989), and education departments (Education Department of South Australia 1988, 1990, 1991) has helped increase the significance of these items as symbols of a hunter–gatherer past.

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[26] McCorquodale (1987) discussed the impact of legislation on Aboriginal issues.

[27] Ornithologists state the number of eggs in one clutch is between four and seven, although over ten has been recorded (Beruldsen 1980: 161). Breeding time is dependent upon water level.

[28] This trend grew through the 1990s, providing a medium for some indigenous people to express their cultural identity (see Bell 1998: 78-89).

FIGURE 2. Lindsay Wilson at the Coorong making a *wadi* club from eucalyptus wood, using a broken plate as a scraper.

Since the 1980s and early 1990s, Lower Murray artists and crafts people have had prominence in the local Aboriginal art and craft market in Adelaide (Hemming & Clarke 1991: 12–14; Sutton et al 1988: 188–190). Aboriginal people such as Paul Kropinyeri and Bluey Roberts specialised in carving. For example, Paul Kropinyeri experimented with making bark spear-deflecting shields, some of which the South Australian Museum purchased (Hemming 1991: 135-6; Sutton et al 1988: Fig. 230). One of his last projects was discovering how to make bark canoes. Bluey Roberts carved mainly emu eggs and boomerangs for sale as art pieces, developing a unique style that incorporated figural elements from both the West Coast side of his family, such as emus and goannas, and the Lower Murray side, usually a Murray cod (DETE 1998: 86-7; Hemming & Clarke 1991: 14; Sutton et al 1988: Fig. 234). As with Paul Kropinyeri, Lindsay Wilson used museum collections as a source of information for reproducing the old style weapons from the Lower Murray. Nevertheless, he was also able to draw upon his own memories of early boomerang and club types (Fig. 2). In the 1930s Lindsay Wilson had assisted Clarence Long in making clubs for sale to Europeans.[29] From the 1980s there was a small market in making realistic representations of pre-European harvesting and fighting implements.

Some artists expressed a close relationship to the landscape, not through making pre-European style objects, but by producing images in Western style art media. For example, Harvey Karpany produced water colour paintings and ink drawings that focused on various Lower Murray spirits and their associated environments (Hemming & Clarke 1991: 14; Sutton et al 1988: Fig. 236). Many Aboriginal people found that his work had a supernatural quality, being 'like *gupas*' (or ghosts). Jack Stengle concentrated on acrylic paintings on board and canvas. He tended to use Lower Murray mythology and history as subjects (Clarke 2001b: pl. 93; DETE 1998: 90–91, 2001a; Sutton 1988: Fig. 237). Older Aboriginal people in the Lower Murray community have played a major role as sources of the cultural and social data depicted in the work of these artists.

The local market for baskets was strong early in the twentieth century when similar 'third world' goods from India and Indonesia were not widely available. In 1909 the Royal Institute for the Blind attempted to get Aboriginal people at Point McLeay to make particular styles of basket to replace the rattan imports from Asia (Jenkin 1979: 214). The reluctance of Aboriginal people to change craft styles is reported to have led to the failure of this initiative. The Point McLeay Mission Station supported the basket-making tradition by placing it on the school curriculum in 1904 (Jenkin 1979: 227). The skill was taught to girls as part of their domestic duties (Wilson 1998: 23). Up until 1951 tourists on paddle steamers came across the lake to visit the mission. Dulcie Wilson recalled that 'Near to the jetty, women from the Mission would display their craft-work, mainly baskets and mats, made from rushes or grasses grown by the lake shore' (Wilson 1998: 25).[30] Basket and mat makers also sold their product to local non-Aboriginal people, before foreign imports from the 1960s priced them out of the market for cheap domestic items. The persistence of indigenous basket-making practices in the Lower Murray was primarily due to continued household use of these items by both Aboriginal and non-Aboriginal people.

In the early 1980s Lower Murray people revived their basketry traditions as part of the building of a local indigenous identity (Fig. 3). Due to the small but steady craft market that developed, this aspect of pre-European material culture has survived in a modified form to the present. Through the 1980s and 1990s the main Aboriginal people making mats and baskets were Ellen Trevorrow and Yvonne Koolmatrie, both of whom were taught the techniques by Dorothy Kartinyeri in 1982 (Clarke 2001b: 111–112; DETE 1998: 104–105, 110–111; Hemming 1989: 48; Sutton et al 1988: 187–188). Museums and art galleries have acquired examples of their work.

The making of flower ornaments from pelican feathers was another distinctive Lower Murray craft of the late twentieth century, although originally introduced from Victoria (Inglis 1961).[31] Women chiefly made these to sell to visitors to the mission station, local farmers and

[29] Clarence Long, also known as Milerum, was considered by Tindale to be the last of the Coorong people with traditional knowledge of the Tangani people of the Coorong (see Tindale 1986: 498–499).

[30] Aboriginal informants remembered, as children, jumping into the lake for coins thrown from the paddle steamers. Trips from Goolwa ended in 1951 when the local steamer was destroyed in a fire (F. Tuckwell, pers. comm.).

[31] Annie ('Fof-fon') Rankine was reputed to have been the first maker of feather flowers in the Lower Murray (J. Chilman, pers. comm.). She experimented with feathers from a number of species before concentrating on pelicans.

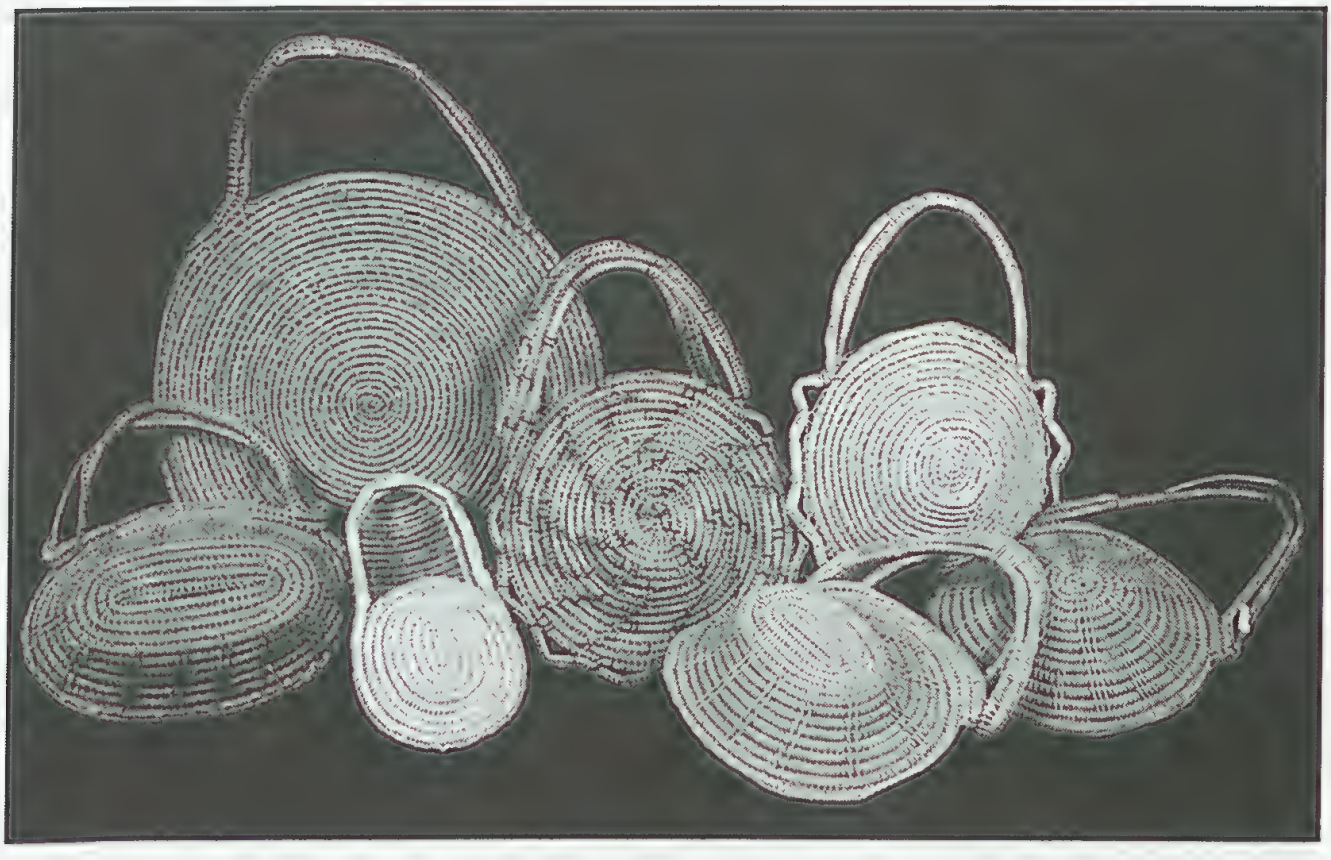

FIGURE 3. A selection of Lower Murray / South East 'sister' baskets. From top left: maker unknown, Mannum, c.1932 (A17530); Ethel Watson, Kingston South East, c.1931 (A15950); Yvonne Koolmatrie, Berri, 1989 (A69209). From bottom left: maker unknown, Manunka, c.1932 (A17524); Ellen Trevorrow, Meningie, 1987 (A65184); maker unknown, Manunka, c.1932 (A16638), maker unknown, Encounter Bay, c.1900 (A2519).

town dwellers (Wilson 1998: 25). In the 1980s the National Parks and Wildlife Service would give permission for Aboriginal people to kill a pelican for its feathers. However, this was only in order to keep the tradition going because, legally, the finished artefacts could not be sold (Wilson et al 1992: 91-2). Aboriginal people occasionally used feathers from a pelican found dead, perhaps killed by the power lines. Alternatively, some people made their flowers from the feathers of bantams and other bird species.

As with other regions of Australia, the sale of artefacts supplemented the income of some extended Aboriginal families. Aboriginal people often earned money by demonstrating their unique craft and art styles to school children and special interest groups. In the 1980s the work of many southern Aboriginal artefact-makers and artists was being promoted through exhibitions and workshops organised by the South Australian Museum and the National Aboriginal Cultural Institute at Tandanya in Adelaide. In the case of the craft people, the knowledge of where to find the raw material in the landscape and the possession of the appropriate 'traditional' artefact-making skills, was considered by them to be an integral part of their Lower Murray culture.

Cultural Importance Of Modern Hunting And Gathering

Hunting and gathering wild food seasonally added to the food supply of many Aboriginal households in the Lower Murray, although its significance diminished in the closing decades of the twentieth century. As demonstrated by Sackett (1979) in the Western Desert, in assessing the importance of foraging activities to the contemporary community, it is wrong to assume that they were simply food-producing activities conducted solely in response to economic and recreational needs. For many Aboriginal people in the Lower Murray, foraging is an expression of their local identity. Hunting and gathering practices have important cultural values, not only

'proving' Aboriginal abilities in obtaining a living from the land, but demonstrating that people have an affinity with and knowledge of the landscape, however altered it is by non-Aboriginal activities. In the 1980s some Ngarrindjeri people associated their families with the totemic symbols (*ngatji*) of the pre-European clans.[32] Most of these are birds, such as the musk duck (*Biziura lobata*), Cape Barren goose, pelican and black swan (Clarke 2001ms). Although these symbols no longer have a role in determining kinship relationships, the knowledge of them serves to reinforce Ngarrindjeri identity. Birds can have a modern symbolic significance as well. In the 1980s Aboriginal people in the Lower Murray adopted the black swan as the Ngarrindjeri emblem, as used, for example, on sporting uniforms.

Modern harvesting practices reinforce an Aboriginal view of the landscape, albeit a recently developed one. An analysis confined to the technology used, often steel traps and shot guns, would not adequately demonstrate the distinctiveness of Aboriginal use of the environment. The cultural importance of harvesting to Lower Murray people is particularly evident in the case of rabbit shooting. One of the advantages of this particular type of hunting is that it is a group activity. The use of a vehicle facilitates much conversation amongst the hunting party. Discussions concern the location of particular geographical features on the reserves, such as water tanks, ruins, old wells, trees, tracks and fences. The dialogue often touches upon past events associated with the scrub and the connecting farmland. Stories are told featuring the past residents of Point McLeay, as well as drawing upon the psychic realm of ghosts, spirit beings and sorcerers.[33] Although, to a lesser extent, this occurs during duck shooting and swan egging, the high level of interaction among the hunters in vehicles is not possible when stalking or ambushing. Sometimes the most in-depth look at the land came when the group, or a part of it, later reflected upon the hunting trip. In their Aboriginal view of the landscape, the harvesting areas are topographically and culturally important sites. Aboriginal participants in shooting parties and swan egging expeditions not only forage for food; they are taking part in occasions for interpreting and experiencing their landscape.

Legislation in the twentieth century, restricting the killing of indigenous birds and prohibiting the taking of their eggs, severely affected Aboriginal bird harvesting practices in the Lower Murray. Although most Aboriginal people interviewed in the 1980s stated that hunters must leave certain species alone due to their scarcity, they perceived the wildlife protection acts as yet another encumbrance placed upon them by white authorities. Added to this were the restrictions placed on vehicular access to the Younghusband Peninsula. When speaking about land use, Lower Murray people stressed that they must be given the rights to continue pre-European-style harvesting practices. Aboriginal people saw no problem with national parks as long as they had access to their resources. During the 1980s local park and wildlife protection authorities allowed some degree of use of the parks for gathering raw plant materials for artefacts and for the shooting of protected faunal species. Some Ngarrindjeri men were employed as park rangers, which facilitated an improved relationship between the local Aboriginal community and the authorities. Nevertheless, the constant monitoring demanded by these activities, such as the individual permits required to shoot a certain number of animals, means that much tends to occur outside the law. Aboriginal people prefer to be discreet about their activities to avoid non-Aboriginal interference.[34] For this reason, Aboriginal people in the Lower Murray often appear to outsiders to be unnecessarily secretive about their hunting, fishing and gathering expeditions.

A number of studies have urged Australian governments to give more formal recognition to indigenous hunting, fishing and gathering rights over both marine and inland resources (Altman et al 1995; Peterson & Rigsby 1998; Resource Assessment Commission 1993: 166–189; Smyth 1993: 211–225). Other reports have considered the role of Aboriginal people in managing wild animal resources (Altman et al 1997; Bomford & Caughley 1996; Parliament of the Commonwealth of Australia 1998; Wilson et al 1992), and the

[32] For a description of the pre-European role of *ngatji*, see Berndt & Berndt (1993: 249–251, 470–473, 417–419).

[33] See Clarke (2002ms) for an explanation of '*gupa*' and '*kuratji* yarns'. Such pre-European style spirits, as distinct from the ghosts of known people, are often associated with areas of old vegetation, such as Block K (Clarke 1999a: 153–155, 160).

[34] Brody (1983) gives a detailed description of the plight of Indian hunters in Northwest Canada, which has some similarities to that of modern Aboriginal hunters and gatherers.

complexity of hybrid economies operating in many Aboriginal communities (Altman 2001). To many Aboriginal people in the Lower Murray, access to the environment and its resources was considered important in spite of landscape changes. From the 1980s this has drawn them into greater involvement in environmental issues.[35] The use of the landscape by non-Aboriginal people is usually not complementary to indigenous harvesting practices.

In the Lower Murray during the 1980s many older Aboriginal people recognised that, in spite of poor social conditions, a few aspects of their own earlier restricted lifestyle were, in hindsight, desirable. The eating of wild foods, in particular, was considered by them to have made their people 'feel stronger' than they do now. Many elderly Aboriginal people expressed great sorrow that the land they knew in their youth no longer exists. These people spoke of the contemporary landscape as being 'sick'. Many of the Aboriginal medicine and food plants and animals were no longer to be found and the waters were now turbid and prone to algal blooms. The reserves where hunting, fishing and gathering could take place were few and small, and generally restricted to the Point McLeay–Coorong area. Nevertheless, some Lower Murray people were able to maintain links with their hunter–gatherer past. Such people, from various backgrounds, stressed the importance of their knowledge and use of local foods for the maintenance of their regional Aboriginal identity. Artefact making, in the style of the 'old people', was important in a similar way. A distinct Aboriginal perception of the physical landscape in the Lower Murray persists, though it is radically different from that which prevailed before Europeans arrived.

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[35] Hemming (1993), Kean *et al* (1991), Mulvaney (1991) and Young *et al* (1991). In the mid to late 1990s the Aboriginal community of the Lower Murray became embroiled in the environmental and cultural debate over the development of Hindmarsh Island. Consideration of this is outside the scope of the present paper.

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MUSEUM VICTORIA
16 JAN 2004

A NEW GENUS OF WATER BEETLE *GENTILINA* GEN. NOV. FROM AUSTRALIA (COLEOPTERA: HYDROPHILIDAE)

FRANZ HEBAUER

HEBAUER, F. 2003. A new genus of water beetle *Gentilina* gen. nov. from Australia (Coleoptera: Hydrophilidae). *Records of the South Australian Museum* 36(2): 109–114.

Gentilina gen. nov. is described and illustrated from Queensland. It comprises one species previously described by Gentili (1993) as *Paranacaena nitens* after a female. The new genus belongs to the subfamily Hydrophilinae, tribe Laccobiini, and comes close to *Hydrophilomima* Hansen & Schödl, 1997 in its external appearance. The aedeagophore of a recent specimen is figured and a revised key to the genera of Laccobiini is given.

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It is not at all surprising to continue to discover new genera of insects from Australia. Many areas of this continent are still undercollected for water beetles. In particular, the Northern Territory was found to support new species of Hydrophiloidea such as *Spercheus wattsi* (Hebauer 1999), *Helochares* spp. (Hebauer & Hendrich 1999), some *Berosus* spp. (Watts 1987) and *Hydrochus* spp. (Watts 1999), as well as Anacaenini and Laccobiini (Gentili 1980, 2000) and a large number of new genera and species of Sphaeridiinae (Hansen 1990). At present there are 45 genera and over 200 species of Hydrophiloidea described from Australia (or 55 genera and over 250 species from the Australian region).

The Hydrophilidae tribe Laccobiini is poorly represented in Australia, until now with the sole genus *Laccobius*. A second genus of this tribe is described in this paper represented by a single species, found at two localities (North Queensland near the Cape Tribulation National Park; and Buderim Mountain). New material is deposited with the following institutions and individuals: Australian National Insect Collection, CSIRO, Canberra (ANIC); Collection of Elio Gentili, Rasa-Varese, Coll. Lars Hendrich, Berlin (CHB); Collection of Franz Hebauer, Grafling, Germany (CHG); Museo di Storia Naturale, Verona (MSNV); Naturhistorisches Museum Wien, (NMW); and the South Australian Museum, Adelaide (SAMA).

Gentilina gen. nov.

(Figs 1–4)

Type species

Paranacaena nitens Gentili, 1993, fixed by designation here. The gender is female.

Diagnosis

Body elongate, widest behind pronotal–elytral junction, contour not interrupted between pronotum and elytra, evenly attenuated posteriorly, weakly convex (Fig. 1). Dorsal face

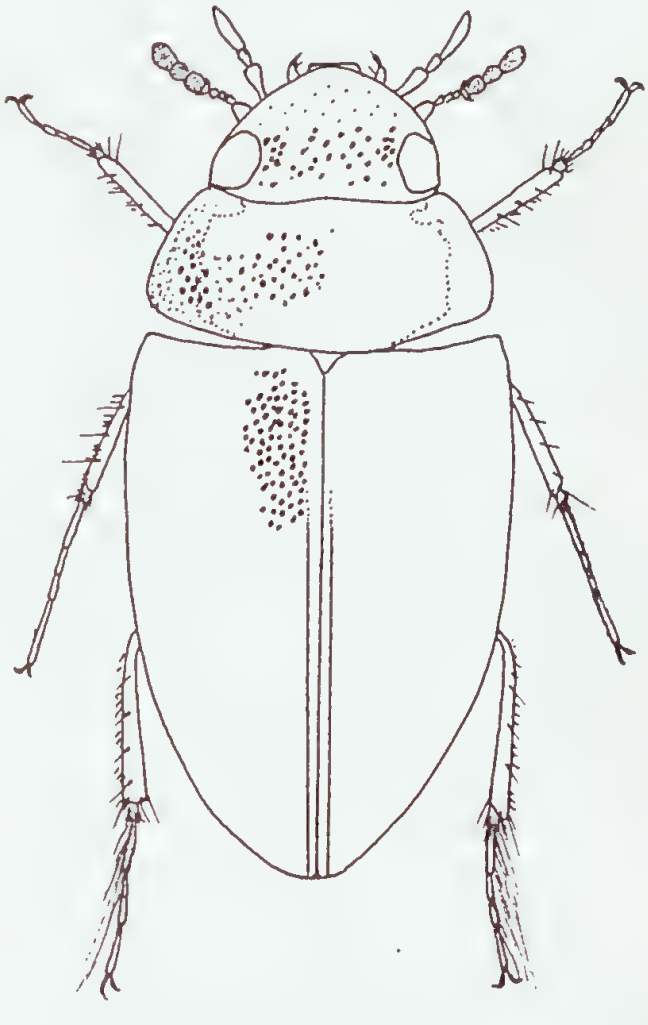

FIGURE 1. *Gentilina nitens* (Gentili), (ANIC), body shape.

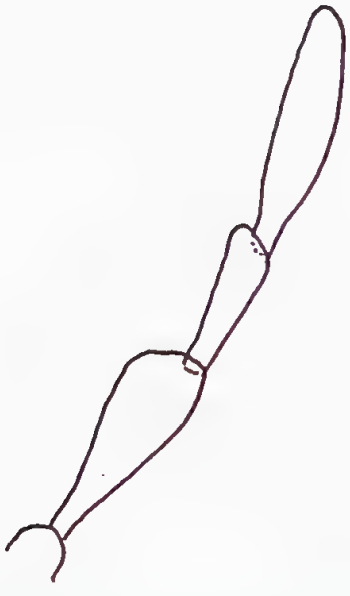

FIGURE 2. *Gentilina nitens* (Gentili), (ANIC), maxillary palp.

glabrous. Clypeus not demarcated from frons by a suture, forming a shelf above antennal base, reaching almost to outer edge of eyes; anterior margin convex, anterior corners rounded. Eyes rather large, separated by about 3x the width of one eye, very slightly protruding from outline of head; anterior margin hardly emarginate. Head slightly narrowed behind eyes. Maxillary palpi half as long as width of head; second segment swollen, apical portion thicker than basal portion; third segment much shorter than second; fourth segment almost twice as long as third, asymmetrical with inner face straightened (Fig. 2). Mentum rectangular, about 1.5x as wide as long, slightly concave, anterior margin almost straight. Labial palpi about as long as width of mentum, slender, cylindrical; second segment without subapical wreath of setae; third segment about as long as second, almost symmetrical. Gula well developed, almost parallel-sided. Antennae 9-segmented, half as long as width of head; first segment of moderate length; second about half as long as first; third to fifth segments very small, subequal; cupule rather small, well differentiated; segments 7 to 9 forming a somewhat compact, pubescent club, which is 3.5x as long as wide (Fig. 3). Pronotum widest at base, sides weakly rounded and strongly narrowed anteriorly; surface evenly convex, without transverse series of punctures at hind margin, but with distinct coarser setiferous punctures forming a short oblique transverse group on each side. Prosternum short, without antennal grooves, not conspicuously elevated medially and without a longitudinal carina; middle portion defined from lateral portions by a pair of very fine oblique ridges; without spines. Mesosternum not fused to metepisterna, only reaching anterior mesothoracic margin at a single point; middle portion rather flat, without a lamina or projection. Metasternum with weakly raised middle portion, not projecting anteriorly between mesocoxae; with hydrofuge pubescence except for a narrow glabrous area on raised drop-shaped middle portion; without femoral lines. Metepisterna parallel-sided, about 6x as long as wide. Abdomen with 5 visible sternites; first and second of about same length, not longitudinally carinate; posterior margin of fifth ventrite subtruncate as in *Laccobius*, not emarginate medially; all ventrites covered with fine pubescence. Epipleura and pseudepipleura well defined from each other, oblique. Elytra slightly convex, evenly attenuated from shoulder to rounded apex, without punctural series, but with sharply impressed sutural stria in posterior two-thirds; rows of coarser systematic punctures hardly traceable. Scutellum of moderate size, triangular, about as long as wide. Coxae with sparse pubescence; anterior and posterior coxae almost contiguous; middle coxae narrowly separated; all trochanters with dense pubescence. Femora slightly flattened, with sharply defined tibial grooves on inner face. Anterior and middle femora covered with dense pubescence except apical portion; hind femora pubescent on basal half and along anterior margin. Middle and hind

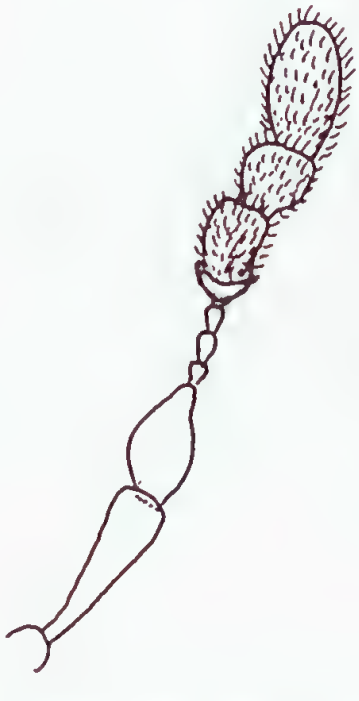

FIGURE 3. *Gentilina nitens* (Gentili), (ANIC), antenna.

FIGURE 4. *Gentilina nitens* (Gentili), (ANIC), hind wing.

femora completely contacting the trochanter basally. Tibiae slender, cylindrical and straight, with moderately long and moderately strong spines on inner face. Tarsi 5-segmented, long and slender, together surpassing length of tibiae; posterior tibiae with a fringe of long and fine swimming-hairs on outer face. The first segment of middle and hind tarsi short; second segment very long; claws rather small, slightly and evenly curved; without sexual dimorphism. Hind wing almost twice as long as elytra; radial cross vein r4 rising from about middle of radial cell (pigmented area at anterior wing margin); medial (cubital) spur rising from apex of medial loop, reaching a little less than halfway towards posterior wing margin; media distinct and united with cubitus to form a M-Cu loop; wedge cell much smaller than basal cell; anal lobe well developed, demarcated from remainder wing by a sharp excision at posterior wing margin (Fig. 4).

Etymology

The generic name refers to my dear friend Dr. Elio Gentili, specialist in the genus *Laccobius* and discoverer of the type species.

Discussion

This new genus has the following diagnostic features of Laccobiini (Oocyclini), as given by Hansen (1991):

- the presence of systematic punctures on head, pronotum and elytra (sometimes not detectable on all three parts; if completely absent then the pseudepipleuron is at least as wide as the true epipleuron anteriorly or is sharply defined from it by a fine ridge
- the apical segment of maxillary palpi longer than the penultimate.

Anacaenini genera of similar size and colour differ from *Gentilina* in the following characters:

- *Paracymus* has the midprosternum sharply carinate and the maxillary palpi shorter than half as long as the width of the head.
- *Anacaena* has no traces of systematic punctures on head, pronotum or elytra; the pseudepipleuron is narrow throughout, much narrower than the true epipleuron anteriorly.
- *Paranacaena* has, in addition, detectable rows of serial punctures on the elytra.

Gentilina comes close to *Hydrophilomima* Hansen & Schödl and, apart from *Scoliopsis* Orchymont and *Tritonus* Mulsant, it is the only genus of Laccobiini with 9-segmented antennae. Besides *Pseudopelthydrus* Jia, it is the only genus of the tribe with the middle and hind femora extensively pubescent. The present known species ranks with the smallest members of the tribe.

Gentilina differs from the genus *Laccobius* mainly in the 5-segmented abdomen, the 9-segmented antennae and the pubescent femora. From *Pelthydrus* it is distinguished by the 9-segmented antennae, the presence of a sutural stria, and the pubescent femora. From *Pseudopelthydrus,* which also has pubescent femora, *Gentilina* is separated by the 9-segmented antennae and the non-keeled first ventrite. In contrast to *Gentilina, Arabhydrus* Hebauer has 8-segmented antennae, its maxillary palpi are distinctly longer (two-thirds as long as width of head) and the second segment is not thickened apically. From the similarly shaped *Hydrophilomima,* the new genus can be distinguished by the middle portion of the mesosternum lacking an elevated portion, the 9-segmented antennae, the swollen second segment of the maxillary palpi being not more than half as

long as the width of the head (about two-thirds in *Hydrophilomima*), the first ventrite being unkeeled, and the extensively pubescent femora (entirely glabrous in *Hydrophilomima*). The genera *Tritonus* Mulsant, *Scoliopsis* Orchymont, *Oocyclus* Sharp and *Beralitra* Orchymont are much larger in size and less easily confused with the above genera because of their striking characters, for example spines, explanate elytra, reniform eyes, acutely pointed hind angles of pronotum.

Gentilina nitens (GENTILI, 1993)
(Fig. 5)

Type material

Holotype (female): Australia: Queensland, Buderim Mtn., Mooloolah, C. J. W. Dec-89 [=1889! C. J. W. = not Watts! The locality is just north of Brisbane] (SAMA).

Paratypes: 4 females as for holotype (SAMA, MSNV).

Additional material: 97 examples: Australia. North-Queensland/Cape Tribulation, Daintree National Park, Turpentine Road, 120 m, 8.xii.1996, Hendrich leg./Loc. 18. (ANIC, CHB, CHG, NMW, SAMA).

Because there is now available a large number of new specimens, including males, a redescription of the species is given here.

Redescription

Length: 1.8–2.0 mm; width: 0.9–1.0 mm. Elongate oval, widest behind shoulders, attenuated behind, moderately convex, black with sides and angles of pronotum widely pale. Head entirely black; clypeus weakly punctate and shagreened, frons rather coarsely and densely irregularly punctate. Maxillary palpi rather long, reaching back to posterior margin of eyes; second segment distinctly dilated on anterior portion, ultimate segment much longer than third, asymmetrical, darkened apically. Antennae 9-segmented. Pronotum widest at base, narrowed anteriorly, shining black with sides and angles broadly yellow; rather coarsely and irregularly punctate; punctured interstices shining. Elytra entirely black, shining, about 1.2x as long as their combined width; coarsely and densely punctate, subseriate; sutural stria sharply impressed in more than posterior half. Irregular rows of coarser punctures hardly traceable. Epipleura oblique. Legs testaceo-brunneous; femora basally darkened; tarsi long and slender, middle and hind tarsi longer than tibiae; with long and fine swimming-hairs. Underside piceous; abdomen 5-segmented, entirely pubescent, first ventrite not carinate medially, fifth segment subtruncate, without apical excision. Mentum rectangular, slightly concave, rugosely reticulated. Prosternum without median carina and without apical notch. Mesosternum only bluntly bulging medially, without a distinct elevation or projection. Anterior and middle femora pubescent except apical portion; posterior femora pubescent in basal half and anterior margin. Aedeagophore with basal piece rather narrow and slender; median lobe filiform, a little shorter than parameres, bifurcate basally. Parameres broad, strongly convex on outer face and straight on inner face, apices pointed (Fig. 5).

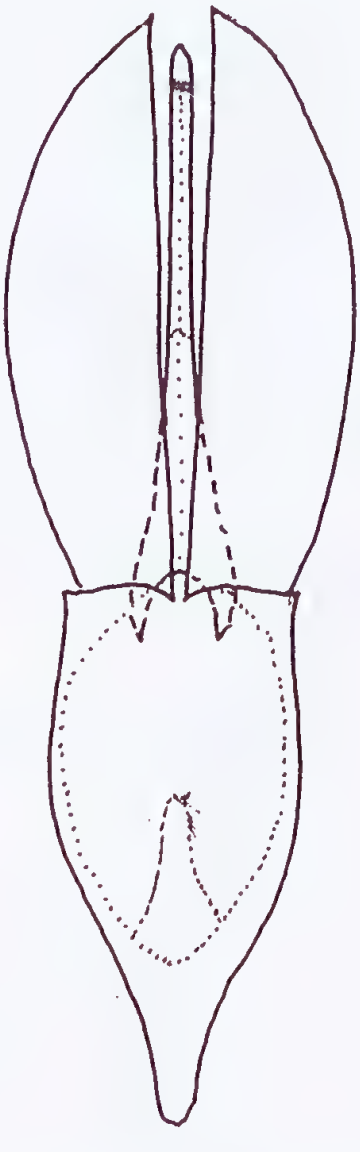

FIGURE 5. *Gentilina nitens* (Gentili), (CHG), aedeagophore.

Distribution

Known only from Queensland. Lars Hendrich (pers. comm.) collected numerous specimens in a small waterfilled rockhole (20 sq cm) in front of a waterfall. The puddle was enriched with some plant debris. The beetles have the habit of flying away immediately when taken out of the water (as in *Agraphydrus* and many *Laccobius*). The small, permanent and almost shaded stream is situated in primary lowland rainforest on private property near the Cape Tribulation National Park.

Revised Key To The Genera Of The Tribe Laccobiini

1 — Maxillary palpi at least two-thirds as long as width of head. Mesosternum broadly reaching anterior mesothoracic margin. First ventrite with median carina, at least basally 2

— Maxillary palpi less than half as long as width of head. Mesosternum only reaching anterior mesothoracic margin at a single point. First ventrite without a keel 5

2 — Anterior and middle femora densely pubescent except at apex, posterior femora pubescent in basal half and/or along anterior and posterior margin. Prosternum almost flat, without median carina—southern China ..... *Pseudopelthydrus* Jia, 1998

— All femora glabrous or pubescent in less than basal half. Prosternum more or less tectiform, with median carina at least anteriorly 3

3 — Abdomen with 6 distinct ventrites. Mesosternum only bluntly bulging posteromedially—Arabian Peninsula (Oman) ..... *Arabhydrus* Hebauer, 1997

— Abdomen with 5 distinct ventrites. Mesosternum abruptly raised posteromedially, forming a strongly margined, elevated portion 4

4 — Metasternum with narrow, somewhat flattened, glabrous median ridge which is connected with median ridge of mesosternal elevation to form a continuous sternal keel. Femora with well-developed tibial grooves on inner face—Oriental region ..... *Hydrophilomima* Hansen & Schödl, 1997

— Metasternum simply convex, often more shiny in middle portion, but without median ridge, anteriorly well demarcated from mesosternum. Femora without well-defined tibial grooves on inner face—Oriental and eastern Palaearctic regions .... *Pelthydrus* Orchymont, 1919

5 — Abdomen with 6 distinct ventrites. Trochanters of posterior legs very large, not completely abutting femora, but with bluntly projecting apices. Posterior tibiae usually curved—worldwide (except South America) ..... *Laccobius* Erichson, 1837

— Abdomen with 5 distinct ventrites. Trochanters of posterior legs of moderate size, not freely projecting apically. Posterior tibiae straight 6

6 — Elytra with distinct sutural stria in about posterior half. Antennae 9-segmented .. 7

— Elytra without distinct sutural stria, but sometimes with the sutures a little elevated posteriorly. Ventrites uniformly pubescent and punctate. Antennae 8-segmented ... 9

7 — Second to fifth ventrites with large well-defined, glabrous and almost impunctate areas medially 8

— All ventrites pubescent—Australia .... *Gentilina* gen. nov.

8 — Posterior corners of pronotum angulate, not produced into a long acute spine. Pro- and mesosternum without spines. Eyes hardly oblique in dorsal view—Mauritius ..... *Tritonus* Mulsant, 1844

— Posterior corners of pronotum produced into a long acute spine. Pro- and mesosternum with some strong spines medially. Eyes obliquely shaped in dorsal view—Sri Lanka .... *Scoliopsis* Orchymont, 1919

9 — Elytra a little explanate towards margin, the suture distinctly raised posteriorly. Body weakly convex—South America .... *Beralitra* Orchymont, 1919

— Elytra not explanate towards margin, the suture not raised. Body often more convex—Oriental and Neotropical regions ..... *Oocyclus* Sharp, 1882

Acknowledgments

My sincere thanks to Dr Chris Watts for his very important suggestions regarding the new genus, and to the *Diplom-Biologist* Lars Hendrich from the Freie Universität, Berlin for donating specimens. Special thanks are due to Prof. Garth N. Foster, Scotland for critically reading the manuscript.

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REPAINT THE DRUM

B CRAIG

CRAIG, B. 2003. Repaint the drum. *Records of the South Australian Museum* 36(2): 115–133.

A large slit-drum from Ambrym in Vanuatu was presented to the South Australian Museum in June 1996. This drum became the catalyst for a review of the museum's collections originating in New Hebrides (Vanuatu) and for an Adelaide Arts Festival event in March 1998. In order to organise the Festival event, the author went to Vanuatu for three weeks, also visiting several locations in central Vanuatu to document items in the museum's collections and to purchase contemporary objects for an exhibition, *Spirits of Vanuatu.*

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The Project

In June 1996 Mrs Claire Murray of Adelaide donated to the South Australian Museum a 2.8 metre high slit-drum (A.74765, Fig. 1) from Vanuatu in memory of her late husband and his deep interest in the music of the Pacific Islands. Claire and Bryan Murray had bought the drum from a shop in Port Vila in 1974. The drum had lost its colours and the Murrays were unable to determine its exact origin and who had carved it.

The receipt of this drum became a catalyst for research on the extensive collections from Vanuatu[1] held by the South Australian Museum. By comparing the style of the carving on the drum with published information (Bonnemaison et al 1996, Fig. 333, second from left; Clausen 1960, Figs 18–21; Speiser 1990, Plate 105, Nr 6), it became clear that the drum was from the island of Ambrym in central Vanuatu.

I read that the slit-drum is likened to the voyaging canoe. The people of Vanuatu are believed to have arrived in their present lands by way of the outrigger canoe some 3200 years ago (Spriggs 1997: 40). They have maintained contact among their many islands since then using large trading vessels.[2]

Clausen believes it was the dugout that provided the model for the slit-drum. The same kind of tree, and the same carving and hollowing techniques, are used, and the forms are similar. He wrote (1960: 19):

> . . . just as the canoes transport man over the ocean and are thus the means by which the ocean can be used, to the benefit of man, for purposes of trade (mainly in boars, sows and small piglets); so also, the slit-drums are like canoes on the ocean of the spirit world, connecting mankind with the otherwise unknown world of the ancestral ghosts whose voices they represent and who live on – literally feed on – the psychic essence of the boars that are sacrificed to them. Slit-drums thus constitute a psychic medium of communication with the spirit world corresponding to the trading voyages of the canoes in external life.

The French ethnographer Joël Bonnemaison (1994) suggests that the voyaging canoe and the networks it creates are metaphorically central to Melanesian concepts of space and time.

Among the northern and central islands of Vanuatu a wide range of goods were traded (Huffman in Bonnemaison et al. 1996: 182–185). These included shell ornaments from the Banks Islands; pottery from the west coast of Santo; red dye from south Santo; green paint from Malekula; woven mats, aprons, belts and baskets from Malekula, Ambae, Maewo and Pentecost; and everywhere pigs were an enthusiastically accepted trade item. Canoes were obtained from northeast Malekula, Lamen, north Ambrym and south Pentecost, because not all the islands had trees large enough to provide suitable hulls. Trade in pigs, foodstuffs, bows and arrows, and shells also took place between inland tribes and coastal

[1] Called New Hebrides until, in 1980, independence was gained from the British–French Condominium, sardonically termed the 'Pandemonium' by some residents.

[2] For an illustration of one of these vessels, see Bonnemaison et al 1996, Fig. 214.

FIGURE 1. Slit-drum (*a-tin-tin*) (A.74765); commissioned by Taimal and carved from breadfruit tree (*pita*) by Tin Mweleun (Golele), of Fanla village, north Ambrym in 1968. Purchased at Port Vila in 1974 by Bryan and Claire Murray, Adelaide. Donated to the South Australian Museum 8 June 1996 by Claire Murray in memory of her late husband, Bryan. Repainted and ritually named 'Fanla' by James Taimal of Fanla and Billy Bong of Ranon, north Ambrym, 12 March 1998. Photo: Trevor Peters, SA Museum.

peoples on the larger islands, facilitated by strategic intermarriage.

Not only objects and materials, but rituals, ritual objects, masks, myths, songs and dances, were traded through a system which respected copyright and required appropriate payments to be made. The more complicated economic transactions involved notions of credit and loans and compound interest. The basic item of value was the pig, the most valuable being those bred with curving tusks, particularly tusks in the form of a double circle. The Swiss ethnographer Speiser said (1990: 246), 'the pig is the standard of value and all other values are related to the pig'.

Thus, in Vanuatu the slit-drum links ritual with canoes and trading voyages; and also masked ceremonies and grade figures with the production and exchange of trade goods (eg pigs and their spiral tusks, shell valuables, and woven mats, pots and pigments).

It occurred to me that the slit-drum donated by Claire Murray could act as a catalyst for the revival of the relationship between South Australia and Vanuatu implicit in the collections held by the Museum. Up until now, South Australians (eg Reverend William Gray, a Presbyterian missionary who served on Tanna, 1882–1895) had gone to Vanuatu and brought back material embodiments of their encounters with the people and cultures of that tropical archipelago. Perhaps now we could invite a ni-Vanuatu man to come to Adelaide to restore the pigments on the drum and ritually install it in the foyer of the Museum.

This would be in accordance with the Museum's current practice of having people from cultures represented by its collections come to the Museum and present aspects of their culture directly to the public. It has happened many times in relation to Aboriginal Australian cultures but only once before in relation to Melanesian cultures – when masked dancers came from New Ireland and East New Britain for the 5th International Pacific Arts Symposium hosted by the South Australian Museum in April 1993 (Chance & Zepplin 1993; Craig 1993, 1994, 1995; Zepplin 1993).

I approached the Friends of the South Australian Museum for a grant to fund the project and this was successful. Enquiries through Dr Darrell Tryon, a linguist at the Research School of Pacific and Asian Studies at the Australian National University in Canberra, provided me with the understanding that the drum could be refurbished and beaten only by a man of

the correct chiefly lineage. In due course I was provided with the name of an Ambrym man working for AustAid at Port Vila who was of the correct lineage. Over the next few months I attempted to arrange for him to come to Adelaide to repaint the drum, but his work commitments led to deferral of the project.

In the meantime, I had urged the Museum to consider supporting exhibition projects consistent with the theme of the 1998 Adelaide Festival of Arts, which was 'Sacred and Profane'. Around the middle of 1997 I was asked if I could organise the repainting of the Ambrym slit-drum as an official Museum event for the Festival. I had realised by then that the only way that such a project could become a scheduled event would be by going to Vanuatu to identify who could come for that particular date, make all the accommodation and travel arrangements, and find out what needed to be provided to make it a successful presentation of Vanuatu culture. I proposed a modest budget to supplement the funds committed by the Friends and this was accepted.

The Objectives

The opportunity to seek out the correct man or men[3] for this work would enable me to do other things as well. My fieldtrip proposal therefore had four objectives:

- To establish a working relationship with the Vanuatua Cultural Centre at Vila by providing for its archives a set of photographs and a computer print-out of around 580 of the South Australian Museum's Vanuatuan objects.[4]
- To add to the documentation of the South Australian Museum's Vanuatuan collections by using these photographs to obtain further cultural information.
- To purchase, and document with notes, photographs and audio tape recordings, and contemporary ethnographic material in Vanuatu to supplement the present collections in the South Australian Museum, and to use these objects in the redevelopment of the Vanuatu exhibits in the Museum's Pacific Gallery.
- To identify, and arrange for, one or two ni-Vanuatu men to travel to Adelaide for the Adelaide Festival of Arts in March 1998 to repaint the Vanuatu slit-drum and perform the relevant rituals prior to its installation in the main foyer of the South Australian Museum.

I also thought it might be possible to find out more about this particular drum by showing a photograph of it to Ambrym men. It happened that in late October 1997 the volunteer fieldworkers of the Vanuatu Cultural Centre would be attending a workshop run by Darrell Tryon and Ralph Regenvanu, the Director of the Cultural Centre. For many years these workshops have been held annually, each year having a different theme.[5] The volunteer fieldworkers meet for two weeks in Vila, bringing videotapes, audio tapes, photographs and information on each year's particular theme gathered from the knowledgable people in their areas. This information and supporting materials are then archived for future reference and research.

There would be men from Ambrym at the workshop; I would be able to show them the photograph of the drum for identification and they would be able to suggest the appropriate persons to come to Adelaide. The fieldworkers also would be able to suggest an itinerary for two weeks of travel through the islands of central Vanuatu for the purpose of gathering information and purchasing contemporary objects for the Museum's collection. Darrell Tryon assured me that my facility in New Guinea Pidgin English would enable me to be understood quite well; Bislama, the Vanuatuan creole, is quite similar to PNG Pidgin. As well, in many of the islands, Vanuatuans have a serviceable ability in English.

In preparation for the trip, Scott Bradley was contracted to photograph the entire collection from Vanuatu. Maria Troiano was engaged as a research assistant for a short time to bring together all the documentation relating to the collections, develop a working bibliography of the history and ethnography of Vanuatu, and identify the main collectors (Table 1). It was clear that a three-week fieldtrip and a modest budget would not be sufficient to visit all the places from which the collections had come (see map, Fig. 2). I decided, therefore, that I should visit:

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[3] Although the repainting could probably be done by one man, it is my experience that village-based Melanesians generally feel uncomfortable travelling in foreign countries, or anywhere outside their own daily sphere of interaction, by themselves.

[4] The actual total appears to be around 670 items.

[5] See Sam, and Huffman, in Bonnemaison et al 1996: 288–293; Fig. 366 shows fieldworkers gathered for such a workshop in 1994.

TABLE 1. Main South Australian Museum collections from Vanuatu.

Collector	Year(s)	Number of items
'Old Collection'	Mostly late 19th century	159
Rev. W. Gray	Collected 1882–1895	about 90
Bishop Cecil Wilson	Early 20th century	66
J.H. Johnson (ex-Young Collection)	Probably late 19th century	49
R.J. Etheridge	Early 20th century	46
Rev. J. Palmer	Late 19th century	35
G.L. Pretty	1971	25
Douglas Mawson	1903	at least 23
Stacey Collection	Late 19th century	22
Dr R.J. Roach (ex-Theodore Thomas, an 'early planter')	Probably late 19th century	18
A. Adamson	Early 20th century	15
M.I. Savage	Early 20th century	14
Australian Board of Missions (Rev. A.S. Webb collection)	Probably early 20th century	11
Other sources	Late 19th–20th centuries	about 100
TOTAL		**at least 670**

- the tiny islands of Wala and Vao (Layard 1942) off the northeast coast of Malekula, which were once thriving bases for canoe trading voyages throughout central Vanuatu;
- Wuss (nowadays called Wusi), a village on the west coast of Santo from where Douglas Mawson purchased three clay pots and other objects in 1903 (Mawson 1957) and where the skills persist to this day (Galipaud in Bonnemaison et al 1996: 97–99);
- Lolowai on east Ambae, where there was an industrious community of women mat-weavers and basket makers (Bolton in Bonnemaison et al 1996: 112–119);
- Ambrym, to see the village from which the Museum's slit-drum came and make arrangements for the repainting event in Adelaide.

The Journey

We[6] spent four days in Vila. I attended the fieldworkers' workshop and recorded information about objects in the South Australian Museum's collections on the basis of the photographs I had brought with me. I was informed that the slit-drum had come from Fanla, a village on the north coast of Ambrym, not far from Ranon. James Taimal told me that his father, Chief Taimal, had commissioned the carving of the drum by Golele in 1968. James and Billy Bong volunteered to come to Adelaide to do the repainting of the drum. This was agreed to by all concerned. So that I could visit the place where the drum was carved, I made arrangements for a launch to pick me up at Craig Cove to take me to Ranon. Billy and James would have returned to Ambrym by that time. Arrangements also were concluded for the visits to the other places on the itinerary.

Malekula

The first stop was northeast Malekula (Norsup) then by road and launch to Wala Island. There I saw a canoe with a carved prow attached, featuring a bird (*soliip*) and flying-fish (*nuwawalades*) motif (cf. Bonnemaison et al 1996, Fig. 51). Although I sought to purchase this, the owner did not want to sell and I later bought a newly-carved one (A.74721) from Malili Kami, a Wala Island Guest House guide (Fig. 3). There were no canoe prows in the collections of the South Australian Museum so this was a significant acquisition, particularly as Malili told me that the *soliip* bird is featured on the prow because it is this bird which navigators use as a guide to land if they get lost out at sea.

The Museum also has two identical masks (A.7430, A.7431, obtained from Reverend Gray, 1895) each topped with a model of a white bird with long narrow wings, a long forked tail and a

[6] I was accompanied by my eight-year-old son, Sai, at my own expense.

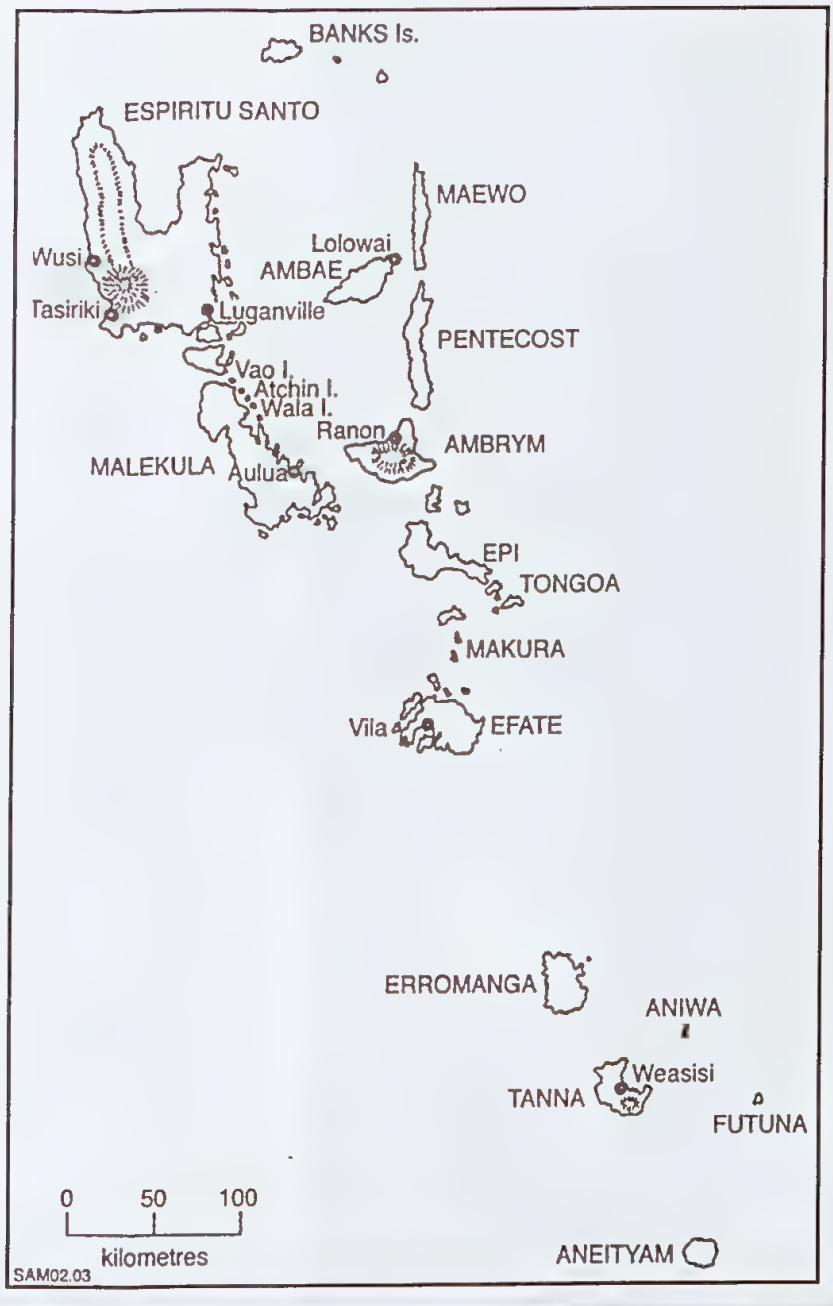

FIGURE 2. Map of Vanuatu.

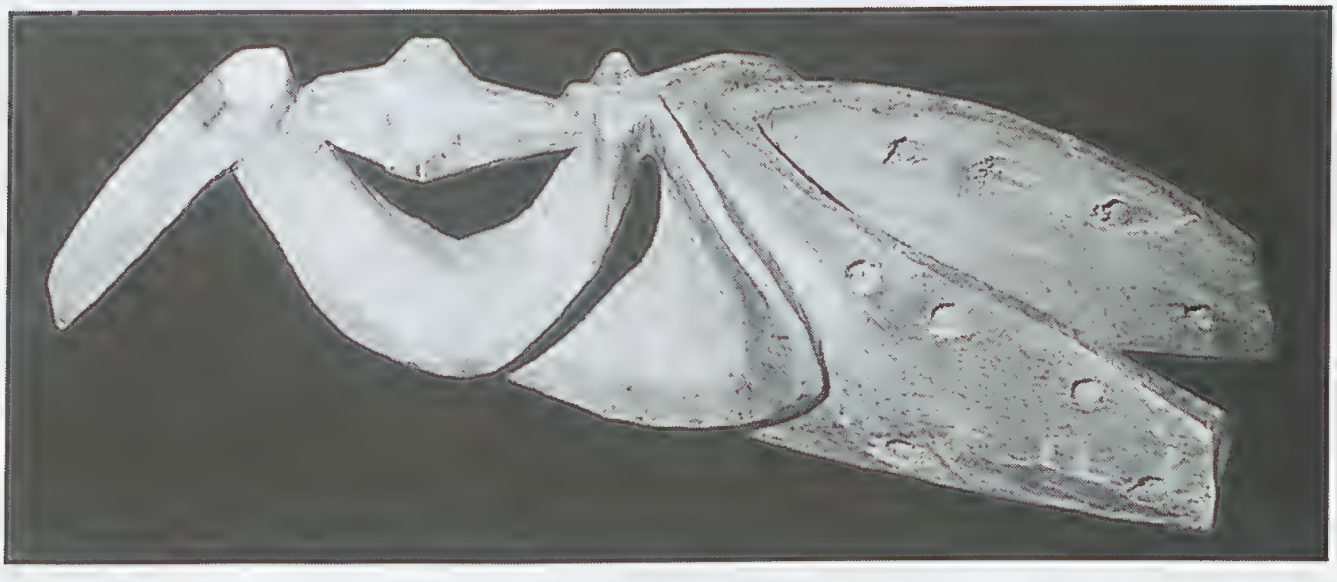

FIGURE 3. Canoe prow (A.74721) featuring bird (*soliip*) and flying fish (*nuwawalades*). Purchased by B. Craig from Malili Kami of Wala Island, northeast Malekula, 1997. Photo: B. Craig.

FIGURE 4. Mask (A.7430) with tern (*soliip*) on top; obtained from Rev. W. Gray 1895. Northeast Malekula. Photo: B. Craig.

black mark on its head (Fig. 4). I asked about this type of mask and was told it was from northeast Malekula, it is called *bang-lulu* and the bird is *soliip*, the same species as on the canoe prow. On return to Adelaide, on the basis of the colour, markings and other characteristics of the bird on the masks, I identified it as most likely the Roseate Tern (*Sterna dougalli*) (Bregulla 1992: 162–163; duPont 1976: 60, Plate 12, E). This information is contrary to Kaufmann's hypothesis (in Bonnemaison et al 1996: 33) and Tilley's conviction (1999: 109–111) that the carved bird on the canoe prow represents the frigate bird. I, too, had suggested this to my informants but they assured me that this was not so.

At the 'Small Nambas kastom village' on Malekula just opposite Wala Island, the people put on a two-hour spectacle of dances, explaining the arrangement of the dance ground (*namel*). There was a spirit guardian figure at the west end (Fig. 5) and a row of ten family shrines (Fig. 6), each featuring a carved post and a carved bird (*nmbel*)[7] with outstretched wings at the peak of

FIGURE 5. Spirit guardian figure at dance ground (*namel*) of Small Nambas Kastom Village, northeast Malekula. Photo: B. Craig.

[7] Coiffier in Bonnemaison et al 1996: 222 (see also Fig. 41) identifies this bird as the sparrow-hawk.

FIGURE 6. Part of a row of family shrines at dance ground of Small Nambas Kastom Village, northeast Malekula. Photo: B. Craig.

the gable (also a feature of men's cult houses on the middle Sepik River in Papua New Guinea – see Craig 1987: Plate 30).

There were several large standing slit-drums, which are beaten with coconuts, and small horizontal slit-drums, which are beaten with short, thick wooden sticks. Several drums were played as an ensemble and the rhythms were quite complex, which surprised me as I am accustomed to the relatively monotonous rhythms of the New Guinea hand-drum.

Some of the dances referred to the planting of yams and of other protective plants around the yam mound. One dance featured the men holding carved and painted paddles, commemorating the first crossing of the people from the Malekula mainland to the offshore islands of Wala, Atchin and Vao. Another dance reminded me of Australian Aboriginal dances as it entailed bird-like movements and gestures, and the kicking-back steps, which raised a lot of dust. The dancers emphasised the rhythm by stomping short bamboo tubes vertically on the ground. Yet another performance featured a pantomime, with one man chasing and beating another who was covered with black ash and hobbling 'painfully' with the aid of a stick, causing men, women and children to shriek with laughter. The women and girls danced in a group separate from the men and boys but it was noticeable that children, even toddlers, were encouraged to join in with the adults.

Although the dances were put on for us as tourists, everyone had a good time and of course they were paid, via a charge levied through the Wala Guest House. A few artefacts were offered for sale, which also provided a source of income. I was assured that the dance ground was used also for traditional grade-taking ceremonies and was therefore not just a tourist attraction.[8]

The next day, on Vao Island I saw partly overgrown *nasara*, ancient ceremonial dance grounds with huge stones set up. Some were still being used for ceremonies, with several large slit-drums in place (Fig. 7).

An interesting cultural feature I noted was the presentation of yams tied to a row of leaning poles, set up for a circumcision ceremony. The likeness to yam presentations among the Abelam

[8] Christopher Tilley (1990: 239–259) provides an extended description and analysis of the 'Small Nambas' dance ground and performances, based on his visit a few years before mine.

FIGURE 7. Slit-drums at dance ground of Vao Island, northeast Malekula. Photo: B. Craig.

of the East Sepik Province of Papua New Guinea immediately sprang to mind (cf. Hauser-Schaublin 1989, Abb. 141).

After photographing the yam displays I was taken to a nearby village house, and Paul Malep showed me a range of carved wooden hand-held masks for sale. These were reminiscent of a mask in the South Australian Museum (A.7760, Fig. 8) mistakenly attributed to Santa Cruz.[9] According to Huffman (in Bonnemaison et al 1996: 23–24), this type of mask from Vao is called *narut* (generic term) and is 'used in tragicomedy mime sketches interspersing stages in the extensive grade rituals'. I was told that some of these masks are named *melo'ombuli* and were used by men to enforce presentation of food by the women during ceremonies. This reminded me of the function of certain *vanis* masks on the Tabar Islands of New Ireland Province, and of the Sulka *keipa* masks of East New Britain Province, Papua New Guinea.

Back on Wala I purchased a stone janus head (A.74723), recently carved by Franco Siptiley, complementing a similar object (A.74720) I had bought at the 'Small Nambas kastom village'. Both are called *dimetsmiel* and represent a spirit that can be induced to make rain, or other desired outcomes, depending on the owner's rights to, and knowledge of, particular spells. Some stone heads are used for pig magic, according to Rodman (in Bonnemaison et al 1996, Figs 195–199).

In the late afternoon I joined a group for a tour of ancient dance grounds on Wala. They have not been used for many years and are overgrown but our guide informed us that there are plans to clear the saplings and bushes that have sprung up, restore the sites and use them for ceremonial

[9] It is almost identical to the one illustrated in Meyer 1995, Plate 18 (L.4103, Linden-Museum, Stuttgart), and similar to the masks in Speiser 1990, colour plate xlviii (Vb 4757, Museum fur Völkerkunde, Basel), and in Bonnemaison et al 1996, Fig. 32 (20933, Musée d'Ethnographie, Genève).

FIGURE 8. Hand-held mask (A.7760), 'Old Collection'; probably Vao Island, northeast Malekula. Photo: B. Craig.

occasions. The old trees and stones lining one side of each dance ground were impressively large, creating an atmosphere of ancient ancestral power. If they revive ritual activities in such places, not only would visitors be impressed, but also the initiates themselves.

Espiritu Santo

The next flight was from Norsup to Luganville on the island of Espiritu Santo. Luganville is the only town in Vanuatu other than the capital, Port Vila. From there we travelled west by road to Tasiriki and by launch up the west coast to Wusi. The west coast of Santo is steep and rocky, with few places to go ashore. Wusi is located on a broad flat area formed by alluvium from a large stream that has cut a valley deep into the mountains. This is one of the few places in the volcanic islands of Vanuatu where clay suitable for making pots could be found. Pots made here therefore were traded widely throughout central Vanuatu.

In 1903 Douglas Mawson spent six months on a geological field trip in Vanuatu. His original field note books and some photographs he took are part of the Mawson Collection, now located in the South Australian Museum. I found that he recorded information of cultural relevance only when he was on the west coast of the island of Espiritu Santo. These references, under the date 16 July 1903, include detailed notes on pot-making (which he later published, see Mawson 1957), a story about a skull he collected (which I have not yet tracked down), and a brief note recording the purchase of a few ethnographic objects: 'Curios: 2 conches, 1 bow & 10 arrows – bone pointed, 1 mat, 1 piece of turtle shell, 3 pots, 1 plate (broke)'.

In the diary it is implied these items were purchased at Wuss (Wusi) as the pot-making was observed there and the note is followed by the comment, 'Had a bad passage down to Tasiriki, landing at 9.55.' However, the 25 Vanuatu items Mawson gave to the South Australian Museum in 1955 only partly correspond to the note quoted above. His donation consisted of the following items:

> One mask (no specific location); one basket (Santo); one apron, 'worn behind to sit upon' (Efate); two spears (no data); one bow (no data); two bows and fourteen arrows (only seven bone-pointed) from Banks Is, obtained from Dr Bowie[10] of the chief mission station on Espiritu Santo who collected them 'long before 1903'; two pots (Wuss village, Santo); one rat trap (Aoba).

A donation of 86 objects by Lady Mawson after Sir Douglas Mawson's death in 1958 included

[10] Reverend F.G. Bowie of the Presbyterian mission, based at Tasiriki.

around 50 pieces from Vanuatu. While many of Mawson's pieces have labels attached, with collection details in his handwriting, others appear to have lost their labels; further research will be necessary to identify all the material from Vanuatu.

Although he does not mention it in his field diaries, the labels confirm that Mawson collected material from locations other than on the west coast of Santo and, to further confuse matters, some pieces may have been lost or given away. For example, there are two Santo pots from Mawson in the Museum (A.48082, -3) and a similar pot (A.29997) from Howchin, a friend and respected senior colleague of Mawson. Perhaps Mawson gave a Wusi pot to Howchin. It is therefore quite possible that these three pots are the three referred to in Mawson's diary.

During the next two days at Wusi, I purchased 21 pots from five women (A.74724–38, 74740–5), nine of which were made by Vera Mei-u (Fig. 9) who is illustrated making pots in Bonnemaison et al 1996, Figs 106–107. I recorded six pot types. I showed Vera Mei-u photographs of Santo pots in the South Australian Museum (from Mawson, Howchin, Gray and Macmillan) and obtained information on what the pots are called, what the designs are called, and what types of food are cooked in them. Information on contemporary

FIGURE 9. Vera Mei-u, potter of Wusi, Espiritu Santo. Photo: B. Craig.

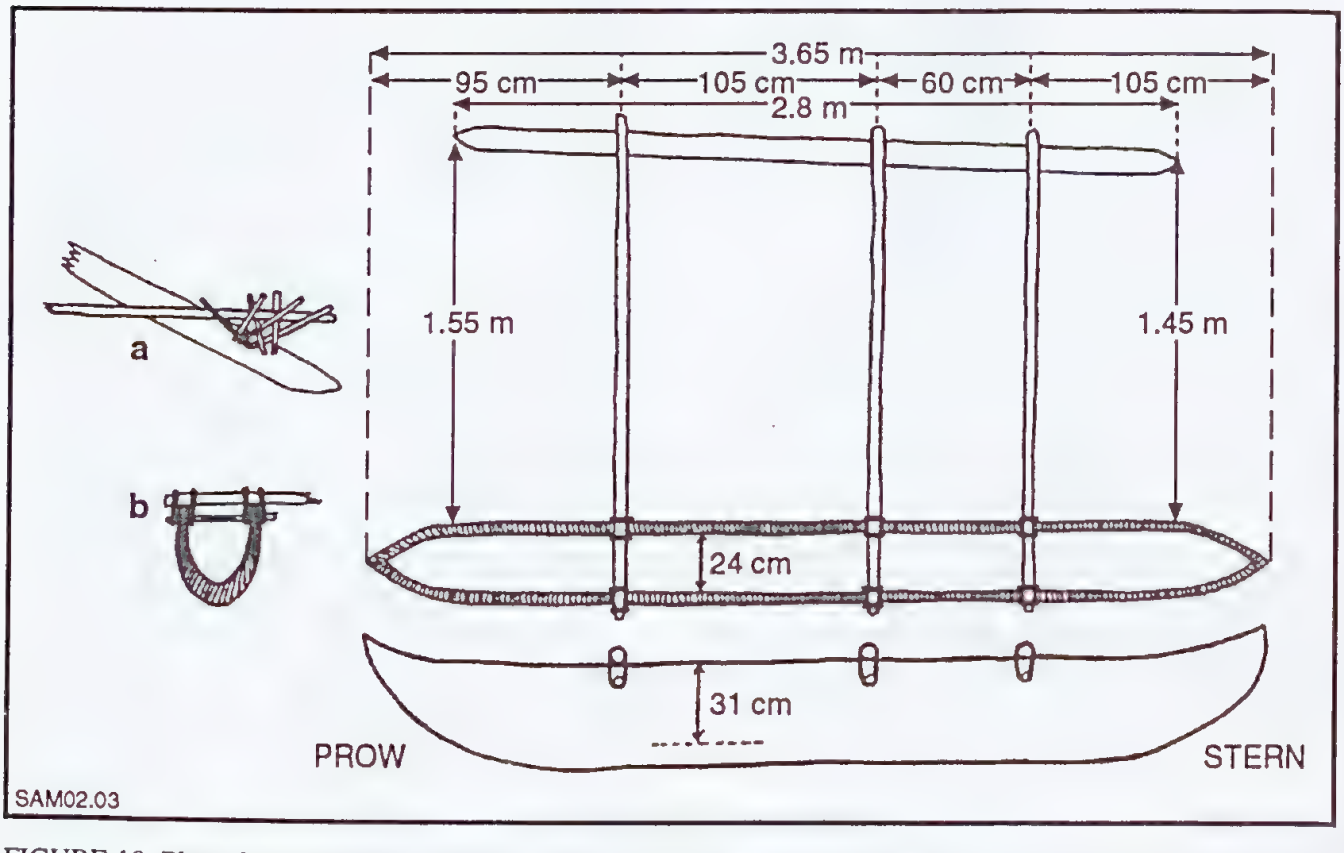

FIGURE 10. Plan of typical outrigger canoe, Wusi, Espiritu Santo. **a.** outrigger attachment; **b.** attachment of boom to gunwale.

pottery has been published by Galipaud (in Bonnemaison et al 1996: 97–99).

There are no longer any of the large trading canoes to be found in Vanuatu but plenty of small outrigger fishing canoes can be seen. Eight were pulled up on the beach at Wusi so I photographed and measured them all. I used the average of these measurements to draw a plan of the 'typical' outrigger canoe of west Santo (Fig. 10). It is interesting that, based on his observations during 1910–12, Speiser wrote (1990: 224), 'In northern Santo...boats are very rare...[and people] on the west and southwest coast of Santo hardly ever venture onto the water'.

Ambae (Aoba)

Returning to Luganville, we flew to Longana on east Ambae and were driven to Lolowai where accommodation had been arranged. Several women gathered to demonstrate their basket-making and mat-weaving skills. We were invited to Lolovoli village to see a drum and dance performance the next day.

This performance perfectly illustrated Crowe's description in Bonnemaison et al (1996: 157):

> In east Ambae slit-gong ensembles, the largest gong is called *ratahigi*, the middle gong *simbegi* and the small gong *valagi*. The ensemble is likened to a voyaging canoe, where the gongs are 'captain', 'helmsman' and 'crew' respectively – the 'crew' may be several small gongs – and on the dance ground the *ratahigi* controls the ritual sequencing (items, stops and starts), the *simbegi* directs the speed of the items in sync with the dancers and the *valagi* provides rhythmic embellishment.

The dance we witnessed at Lolovoli, called *tikor,* was accompanied by five slit-drums – a large *ratahigi* over 2 metres in length; a *simbegi* just over a metre and a half in length; two *valogi* about a metre in length and a small *valogi* just over half a metre long. They were arranged in a horizontal position in an open-sided hut next to the dance ground and were undecorated (Fig. 11).

The 'captain', Joseph Maori, was an old man, strong and steady, laying down the basic rhythms. The 'helmsman' was Edward Garai, wiry, full of vigour, flashing his teeth, his whole upper body animated with the complex beats by which he directed the tempo of the dozen dancers led by Aaron Ang'ga. The three 'crew' – David Boi, Moses Tafoa and another man – ornamented the progress of the work.

FIGURE 11. Drum ensemble performing at Lolovoli, west Ambae. Photo: B. Craig.

FIGURE 12. Women weaving mats, Lolowai, west Ambae. Photo: B. Craig.

The drummers' and dance leader's names reflect the history of Christian missionary activity in these islands but 'kastom' persists alongside the new ways, and there is no conflict in their minds between the notion of respect for the ancestors and respect for the Christian God.

The next day I was presented with a written program of activities demonstrating the processes of weaving and dyeing mats.[11] Apart from pigs and pig tusks, perhaps the most important trade items in central Vanuatu were the mats woven by women (Fig. 12) from strips of pandanus leaf (*Pandanus tectorius*), often with abundant fringes and using designs dyed a brownish-red. This dye used to be obtained from the bark of *Ventilago neocaledonica*, but the women said that this plant is increasingly difficult to find so nowadays they buy imported red, purple and blue dyes from the trade store. They still use a yellow dye from the grated rhizome of a plant called *ang'or* (turmeric?). In the southern half of Vanuatu it would appear that tapa cloth performed some of the same functions as mats in the northern half, but tapa is rarely made today.

To prepare a mat for dyeing, it is first tied around a log of suitable circumference. Linear geometric designs are produced by binding short strips cut from the stems of *Heliconia indica* over the mat using a rope that is permeable to the dye to produce white motifs on a coloured ground; this type of mat is called *singo* on east Ambae. More complex, curvilinear motifs are achieved by binding on stencils cut from layers of the trunk of a banana plant; this type of design is used on mats called *gwana*. Long mats, either uncoloured or dyed in a single block of colour, are called *maraha*.

When the mat has been prepared it is then laid in a galvanised iron trough of hot dye which simmers over the flames for 15 to 30 minutes. The mat is then taken out of the trough, the stencils are removed and the mat is dried in the sun.

The *gwana* mats may be worn by women as clothing or may function as blankets and floor mats; *maraha* may be used to wrap the dead; *singo* are worn by men and indicate status in the grade system. *Gwana*, and especially *maraha*, are used as items of exchange, functioning as traditional 'money'. They are most important as marriage gifts from bride's family to bridegroom's family (Bonnemaison et al 1996, Figs 122, 123, 129), symbolising the fertility of women in opposition to the curved pigs' teeth which represents men's reproductive substance (Walter in Bonnemaison et al 1996: 108).

Baskets of all shapes and sizes, some with intricate coloured designs – including names – woven into them, are also of great importance as containers and carry-alls, there being no tradition here of looped string net bags as in Papua New Guinea.

Following the demonstration of weaving and dyeing, dozens of mats and baskets were laid out for me, from which I chose seven mats (A.74748, 74750-55) and four baskets (A.74746, -47, -49, -56) of different types for the Museum.

[11] For a brief description of the social significance of mats and of mat-making and dyeing on Ambae, see Bolton in Bonnemaison et al 1996: 112–119; and for an extended study, see Bolton 1993. Eleanor Williams (1928) reported mat-making on Pentecost Island.

FIGURE 13. Dance ground at Fanla, north Ambrym, showing slit-drums, grade figures and men's house. Photo: B. Craig.

Ambrym

We flew back to Luganville and caught the plane to Craig Cove, west Ambrym, for the final stage of the fieldtrip. An outboard-powered launch took us to Ranon on the north coast, where we were met by Billy Bong and shown to a little Church-run guest house. I noticed a carvers' workshop on the beach with several unfinished slit-drums and grade figures inside. I arranged with Billy to visit Fanla, a village up on a ridge a few kilometres east of Ranon, the next day. This was where the slit-drum bought by Claire and Bryan Murray had come from. That night we slept with the sulphurous fumes of Mt Benbow drifting through the village.

The next day we walked up to Fanla and found James Taimal, and I obtained further information about the slit-drum (*a-tin-tin*) at the South Australian Museum. It had been carved by Golele (also known as Tin Mweleun) under commission from Chief Taimal (James's father) around 1968 from a breadfruit tree log (*pita*). I photographed the dance ground with its slit-drums, grade figures and men's house (Fig. 13), and purchased for the Museum one of the unpainted grade figures (*mage*) carved from tree-fern (*palang*) by Alili Molkaun about 1990 (A.74757).

The sacrifice of pigs is essential for all ritual occasions, especially when men seek to move upwards in the competitive grading systems. A visible marker of grade-taking is the tree-fern or wood figure carved by the grade-taker and erected on the dance ground. Bonnemaison says of grade-takers in south Malekula (Bonnemaison et al 1996: 209),

> As he rises, the man of high grade becomes a supernatural being, hedged about with numerous tabus and kept carefully apart from the world of the 'living'...the man of high grade here is a man who has joined the community of his ancestors.

FIGURE 14. Chief Pong Randi of Ranon, north Ambrym, playing mouth-bow. Photo: B. Craig.

We returned to Ranon and arrangements were concluded with Billy and James for their travel to Adelaide in March to repaint the slit-drum. They were to bring red, white and black pigments, a mallet and chisel for demonstration carving, and powdered kava for the feast to follow the installation of the drum. I agreed to supply a pig, taro, yam and sweet potato for the feast.

Before returning to Craig Cove the next day, we were invited to hear Chief Pong Randi demonstrate his musical skills using a mouth-bow (*yutoto*) and a long, end-blown bamboo flute (*liblabo*). I photographed the Chief playing a few songs on each instrument (Fig. 14) and was able to purchase them for the Museum (A.74759 and A.74758 respectively). These instruments were virtually identical to those obtained by the Museum from Reverend Gray in 1895 (A.29998 and A.8387 respectively).

At Craig Cove I was handed a letter by Ramel Bong for the Director of the South Australian Museum regarding the concerns of the men of west Ambrym about a *rom* mask in the Museum's collections (cf. Bonnemaison et al 1996: 327–329, Fig. 18). This mask (A.7433 – see the cover of Ling 1982) was collected by Douglas Mawson in 1903. It is not currently on display although it used to be, at least from 1949 until around 1992. The men of west Ambrym stated categorically it should not be placed on public display and must not be seen by anyone not of the proper grade, although they had no concern about the display of photographs of it. However, the letter proposed that we could pay 50,000 vatu (approx. Aust. $600) to obtain the right to exhibit the mask.

The *rom* mask's specific name is *bati pasel* and it is normally destroyed after the ceremony in which it is used. I took the opportunity to explain the SA Museum's policy, and facilities, for dealing with Aboriginal secret–sacred material and suggested that we could do the same sort of thing for this *rom* mask if the Director decided not to purchase the right to display it.

In Vila I spent the next two days packing the collection, getting it fumigated by Quarantine and obtaining export permits from the Vanuatu Cultural Centre. Arrangements were made with Ralph Regenvanu, the Director of the Cultural Centre, for ensuring that the trip to Adelaide by Billy Bong and James Taimal would proceed smoothly. I reflected with surprise that the whole trip had gone like clockwork.

The Results

Establish a Working Relationship between SA Museum and the Vanuatu Cultural Centre

Before departing for Vanuatu, almost the entire collection of around 580 Vanuatuan objects, both on display and in storage, was photographed and the prints placed in two photo albums. Reference numbers and collection registration numbers were written beside each photograph and a computer print-out was included.

The album provides an understanding for the Vanuatu Cultural Centre of what types of objects we have in our collections in Adelaide. This may be of assistance for planning exhibitions in Vanuatu of material not held in the Centre's own collections but which could be sent on loan for that purpose. It may also be useful for identifying material for repatriation should that become an issue. Reference to individual photographs may also be of assistance in gaining further information, by email and correspondence, about the objects depicted in them.

Documentation of SA Museum pieces on the basis of photographs

The photograph albums were circulated among the Cultural Centre fieldworkers during the last few days of their workshop, which I attended. The photographs excited a great deal of interest and several people provided information about the objects depicted. This has added considerably to knowledge of the origins and significance of the pieces in the collections.

There wasn't sufficient time during the workshop to go through all the photographs to document all of the 580 pieces in the collections. However, I did manage to check all of the woven mats and baskets with Mrs Jean Tarisese of the Vanuatu Cultural Centre. She explained the apparently incorrect provenances of some of the mats; for example, two mats collected in Erromango (A.63021, -2) were most likely made by an Ambae woman whose family was relocated to Erromango by Europeans, and a mat collected in Malekula (A.42469) was almost certainly traded from Ambae.

The tapa cloths were checked with a fieldworker from Erromango, who also corrected provenances. For example, three cloths (A.60480–2) recorded to be from Banks Islands, collected by Archdeacon E.A. Codd and donated in 1970, are definitely not Vanuatuan, as blue-dyed tapas are unique to the Solomon Islands (cf. Neich and

Pendergrast 1997: 128).[12] Codd ran a Melanesian Mission boarding school on Banks Islands but was also for a time Warden of the Teachers' Training College at Seota on Florida Island so he could have obtained the tapas from a Solomon Islands student attending either of those institutions. Three other cloths are definitely not Vanuatuan. Two stencilled tapas (A.37472, 37504), obtained from F. Whitby in 1900 and recorded to be from Havannah Harbour, Efate, are Samoan or early Tongan in type (cf. Neich & Pendergrast 1997: 35, 40) and a third (A.37473) is clearly Tongan (cf. Neich & Pendergrast 1997: 48 bottom). Neich and Pendergrast (1997: 22–23, 155) have noted that tapa cloths often were collected in places far from their geographical or cultural origin, for example when items were moved by trade or when Polynesian mission families were posted to Melanesia.

Five tapas were recognised to be from Erromango in southern Vanuatu – two from the northwest coast (A.56589a, 63020) and three from the southeast coast (A.56589b, 63018, -19). A repeated lozenge design (*nirom*) on the tapas from the northwest was associated with warfare. The designs on the other three were said to represent certain birds (*unkil* and *menuk roya*) and flowers (*niyor*), but the significance of these motifs was not stated.

These tapa cloths from Erromanga, called *nemas-itse*, were used 'as women's clothing and for local barter as well as for carrying babies' (Lawson 1994: 64). Huffman in Bonnemaison et al (1996: 129–140) provides further information about bark cloth in Vanuatu, how it was made and used, and its sociocultural importance.

The photographs of the clay pots were shown to women at the village of Wusi on Santo, who provided additional information. These included the two pots (A.48082, -3 – *uro-turi* and *uro-vela* respectively) collected and described by Douglas Mawson (Mawson 1957), the one (A.29997) donated to the Museum by Howchin and probably collected by Mawson, one from Rev. William Gray (A.8351) and six from Rev. T. Macmillan (A.8349, 8350, 8352–5), who took over on Tanna when Gray left.

Some information was recorded regarding the circular 'stone money' of Erromango (A.8452) and the crescent-shaped lumps of clam-shell (A.8453–5). I was informed by James Atnelo that the rings of stone were called *navela,* and were cut from soft limestone then buried for a few years until they hardened up to resemble marble. Speiser (1990: 244–245), who records them as *navilah*, reports that they were not quite like 'money' in that they had no fixed value and were not used in daily trading. I was told they could be used for bridewealth, to pay blood debts and funerary debts, and to make peace. The round ones (*navela*) represent the full moon; the crescent-shaped clam-shell and stone equivalents (*navelong kone*) represent the crescent moon; the former are used only by chiefs and the latter by lower ranks. A *navela* is known by the names of the important women it has been used to 'pay for'.

A canoe model (A.8037) was identified by a workshop participant as coming from Makura in the Shepherd Islands. After I returned to Adelaide, I came across a handwritten list of the collection bought in 1895 from Rev. William Gray. This list includes a model canoe from Tongoa, which is in the Shepherd Islands only 25 kilometres from Makura. This data had not been transferred to the register. Another model canoe in the Gray Collection list is from 'Aneiva', which is undoubtedly Aniwa. This must be A.8039, which appears in the Museum's register as 'Old Collection, New Hebrides'. A photograph of this canoe model was not available for inspection by Cultural Centre fieldworkers to confirm the Aniwa provenance (and by implication that it is part of the Gray Collection), but comparison with Haddon and Hornell's sketch of a canoe from nearby Futuna (1937, Fig. 9) supports this identification.

Photographs of six of the masks in the Museum's collection were shown to a number of men to elicit information about them. Two masks (only one photographed) with the white bird on top (A.7430, 7431) from Rev. Gray in 1895 have been mentioned above. A similar mask, but without a bird, from Rev. F. Whitby in 1900 (A.7429) has been on display for at least 50 years. Although documented as from 'Vote Island' (presumably Vaté, ie Efate), it is from 'Small Nambas' (northeast Malekula) according to informants, and is called *ben'gelo.*[13] It seems to be the same type of mask as that described by Huffman (in Bonnemaison et al 1996: 21, Fig. 20) as the 'round head' (*botmolmoli*) type.

Two masks from Malekula – A.7432 from Rev.

[12] The SA Museum has a similar blue-dyed tapa (A.8270) from Santa Isabel in the Solomons collected by Bishop Cecil Wilson.

[13] This could be the same as the term I heard, slightly differently, for A.7430 – *bang'lulu.*

F. Whitby, 1900, and A.7758 from the 'Old Collection', 19th century – may be compared to Speiser 1990, Plate 99, Nr 2 and Plate 94, Nr 6 respectively. The only information I could gather was that they were from southern Malekula.

Concern was expressed about the *rom* mask, A.7433, as noted above (but not about A.52465 that appears also to be an Ambrym *rom* mask, nineteenth century, transferred to the South Australian Museum from the Port Adelaide Institute). When I returned to Adelaide I discovered that the former had been given to the Museum around 1906 by Douglas Mawson after he took up a position teaching geology at the University of Adelaide. I read through Mawson's New Hebrides field diaries, which indicate that he travelled through the archipelago by boat and on 12 August 1903 made a few observations, from the deck, at Dip Point (West Ambrym) but there is no mention of going ashore or of collecting the mask there. In one notebook there is a list of things for him to do and on the list is 'Obtain a mask'. It is likely, therefore, that he obtained one in Port Vila from another collector or a trader. In the Mawson archives there is a photograph of him wearing the mask in front of the southeastern corner of the Quadrangle at the University of Sydney during a graduation day charade. Standing on a horse-drawn wagon, his skin blackened, Mawson wears the mask and a grass skirt, and a 'missionary' stands beside a large cooking pot (Pharaoh & Craig 2001).

The South Australian Museum has 17 overmodelled and painted skulls from southern Malekula (A.9756, 11461–75, 12165). Speiser says of northern Vanuatu, 'the head was regarded as the seat of life and the soul, and consequently, after death, the skull was treated with very special reverence' (1990: 319). When a high-ranking man died, his skull was cleaned and overmodelled with a mixture of coconut fibre, clay and fig tree sap to produce a portrait; the head was then painted with the pattern representing the man's rank in the grade system (Speiser 1990: 275). These memorials of the dead were placed on a pole carved with anthropomorphic features (Speiser 1990: Plate 81, Nr 13; Plate 82, Nr 2); or, in the case of the highest-ranking men, the whole body was modelled in plant materials, with the portrait skull set on its neck, and kept in the men's house (Bonnemaison et al 1996, Fig. 243; Speiser 1990: 349, Plate 80, Nr 3). These memorial effigies are called *rambaramp*.

Because of the concerns of Australian Aboriginal people about museums holding Aboriginal remains, I asked the Director of the Vanuatu Cultural Centre whether the display of portrait skulls was a problem for Vanuatuans and he replied that he had never heard such concern expressed. Consistent with this was the response from the Vanuatu Cultural Centre's previous Director when Michael Quinnell of the Queensland Museum asked about whether there would be any objections to displaying the Malekulan *rambaramp* figure in that museum's

FIGURE 15. Grade figure (A.7448), New Hebrides, 'Old Collection'; collected by Rev. T.W. Leggatt from Barabitam Asing of Sah Sun Bay, south of Aulua, southeast Malekula, and passed on to Rev. W. Gray. Photo: Scott Bradley.

collections (Hamlyn-Harris 1915) and only encouragement was given (M. Quinnell, pers. comm. 25 June 1998).

These results confirm the value of returning to places where artefacts have come from, even a century ago, to recover more information about the objects from the memories of people living today and to check whether exhibition of certain material continues to be permissible.

Acquisitions for future exhibits

I visited specific locations in Vanuatu to purchase objects equivalent to certain pieces in the South Australian Museum's collections. I obtained 21 clay pots from the village of Wusi on Espiritu Santo which are smaller than, but in other ways comparable to, those from around a century ago. I also purchased seven mats and four baskets from Lolowai on the island of Ambae, to compare with the excellent old pieces we have from that island and from Pentecost and Maewo.

Previously we did not have an example of a carved canoe prow and I was able to obtain one. The flute (cf. Bonnemaison et al 1996: 150–153) and mouth-bow from Chief Pong Randi of Ranon, Ambrym, are comparable to the mouth-bow from Ambrym[14] and the end-blown flute from Malekula mentioned above.

Of considerable interest too is the carved 'black-palm' (tree-fern) grade figure (cf. Bonnemaison et al 1996, Figs 325, 335) purchased from the dance ground at Fanla from which the slit-drum came. It complements the late 19th century grade figure (A.7448, Fig. 15) of carved and painted wood which almost certainly was collected by Rev. T.W. Leggatt in southeast Malekula and is part of the Gray Collection (see Craig, in press).

These comparative materials formed the basis for a special exhibition, 'Spirits of Vanuatu', in the South Australian Museum's Pacific Gallery commencing March 1998. This exhibition brings

FIGURE 16. James Taimal repainting the slit-drum at the South Australian Museum on the occasion of the Adelaide Festival of Arts, 1998. Photo: Andrew Hughes.

[14] The old handwritten list of items obtained from Rev. William Gray includes '1 Malecula flute' and '1 Harp (Ambriam)'. This list apparently was not seen by the person who registered the mouth-bow in 1941, as the provenance is given as 'Espiritu Santo' and a reference to Edge-Partington, Series III, p 60 is provided in the Remarks column. This reference is to a British Museum specimen from Espiritu Santo. Speiser (1990) illustrates one, which he calls a Jew's Harp, from Ambrym in Plate 102, Nr 5.

to the attention of the Museum visitor the continuity of tradition in a context of change.[15]

Repaint the Drum – the Festival event

James Taimal and Billy Bong had nominated themselves to go to Adelaide to repaint the drum. James had the rights to carve and paint and Billy could assist. The fieldworkers at the workshop had agreed with this proposition.

The cost of passports and visas for the two men, boat travel, meals and accommodation, and an honorarium for each man were met from the project budget. Free air travel was provided for them by Vanair, Airvanuatu and Ansett Airlines.

The repainting event was scheduled for Thursday 12th March. Billy and James arrived in Adelaide Tuesday morning, 10th March. This provided two days to inspect the slit-drum, to look through the Pacific Gallery – especially the Vanuatu exhibits – and become familiar with the venue, to ensure all the necessary equipment and materials were available, to cut a 1.5 metre length of pine for James to demonstrate the carving of a grade figure, and to provide advice about the cooking of the pig and vegetables in a 'ground oven' and the preparation of kava drink from the powdered form they had brought with them from Vanuatu. We were also assisted in the preparation of the food and drink by a number of Melanesian volunteers living in Adelaide.

The carving, painting (Fig. 16) and ground oven were of considerable interest to school students, staff of the Museum and curious passers-by, and elicited many spontaneous and favourable comments. One example was the family from Adelaide's northern suburbs who had come in to the city to see what was happening and stumbled on the event by chance. They commented that it was a pleasant surprise to come across an event which belied the commonly held belief that museums are storehouses of dead things.

A couple of youths with colourful tattoos on their arms and on their shaved heads attracted the favourable interest of James and Billy, who fell into conversation with them. As a result of being treated with respect by people whose culture accepts tattoos as a sign of high status, these youths offered their help in clearing up the grounds afterwards.

A special guest at the repainting event was Xavier Minniecon, a well-known Adelaide television identity. Minniecon's great grandfather had been 'blackbirded' from Craig Cove to work on the Queensland sugar plantations and had not returned home. Instead he had married a European woman and settled in Australia. Minniecon spoke of his childhood 'on the wrong side of the tracks' and of his determination to make a go of it. He succeeded but felt a gap in his knowledge and experience regarding Vanuatu, as he had never been there. The invitation to be associated with the 'Repainting the Drum' event was for him an opportunity to explore his cultural and genetic roots and he spoke eloquently on behalf of racial and cultural tolerance.

The tables had turned. Previously it was the white people who went among the Melanesians to convince them to live in harmony; now it was the turn of the Melanesians to take that message to the white people.

ACKNOWLEDGMENTS

This project happened because Claire Murray generously donated the slit-drum to the South Australian Museum; and because the Friends of the South Australian Museum provided funding and the then-Director of the South Australian Museum, Dr Christopher Anderson, supported the project as a Festival event. Dr Darrell Tryon (Australian National University) and Ralph Regenvanu and his staff at the Vanuatu Cultural Centre provided information, practical advice and encouragement for the fieldwork component of the project. Several ni-Vanuatu volunteer fieldworkers helped with the logistics and hospitality in the islands. James Taimal and Billy Bong made the Festival event a resounding success. Maria Troiano's research was invaluable and Scott Bradley's photography was crucial to the project. Xavier Minniecon generously gave of his valuable time to help with the feast and dedication of the drum at the Festival. Vanair, AirVanuatu and Ansett Airlines provided fares for James Taimal and Billy Bong, and Helen and Paul Dennet looked after them in Sydney. Several Pacific islanders living in Adelaide volunteered to help cook the pig and vegetables in the ground with hot stones.

[15] The information sheet which accompanies this exhibition may be viewed on the South Australian Museum's website, at <www.samuseum.sa.gov.au/info_sheets.htm>, and click on 'Vanuatu'.

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TWENTY-FIVE NEW DYTISCIDAE (COLEOPTERA) OF THE GENERA *TJIRTUDESSUS* WATTS & HUMPHREYS, *NIRRIPIRTI* WATTS & HUMPHREYS AND *BIDESSODES* REGIMBART FROM UNDERGROUND WATERS IN AUSTRALIA

CHS WATTS & WF HUMPHREYS

WATTS, CHS & HUMPHREYS, WF. 2003. Twenty-five new Dytiscidae (Coleoptera) of the genera *Tjirtudessus* Watts & Humphreys, *Nirripirti* Watts & Humphreys and *Bidessodes* Regimbart from underground waters in Australia. *Records of the South Australian Museum* **36**(2): 135–187.

Twenty-five new species of stygobitic Dytiscidae from inland Western Australia and Central Australia are described: *Tjirtudessus bialveus* sp. nov., *T. cunyuensis* sp. nov., *T. jundeeensis* sp. nov., *T. karalundiensis* sp. nov., *T. macrotarsus* sp. nov., *T. silus* sp. nov., *T. sweetwatersensis* sp. nov., *T. wilunaensis* sp. nov., *T. yuinmeryensis* sp. nov., *Bidessodes limestoneensis* sp. nov., *B. gutteridgei* sp. nov., *Nirripirti darlotensis* sp. nov., *N. fortisspina* sp. nov., *N. hamoni* sp. nov., *N. killaraensis* sp. nov., *N. macrocephalus* sp. nov., *N. melroseensis* sp. nov., *N. milgunensis* sp. nov., *N. napperbyensis* sp. nov., *N. newhavenensis* sp. nov., *N. pentameres* sp. nov., *N. plutonicensis* sp. nov., *N. stegastos* sp. nov., *N. skaphites* sp. nov. and *N. wedgeensis* sp. nov. The genus *Nirridessus* Watts & Humphreys 1999 is synonomised with *Tjirtudessus* Watts & Humphreys 1999.

This brings the total of stygobitic Dytiscidae described from Australia to 42 species in three genera. Two of the new species are placed in the genus *Bidessodes* Regimbart, representing the first stygobitic members of the genus. Geographically the new species greatly extend the range of stygobitic Dytiscidae in Australia to include Central Australia. As before (see Watts & Humphreys 2001) the stygofauna was found together with a rich stygobitic fauna in those portions of shallow aquifers that ran through areas of calcrete formation.

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This is the fourth paper in what has become a series of papers describing the stygobitic Dytiscidae of Australia (Watts & Humphreys 1999, 2000, 2001). In it we describe the new species found during fieldwork in Western Australia and in the Northern Territory in winter 2001 and discuss the associated stygofauna and chemical profiles of some of the aquifers in which the species were found.

Twenty-five new species are described, which significantly extends both the geographic and taxonomic range of the fauna. A rich fauna has been discovered in aquifers in the Ngalia Basin northwest of Alice Springs in central Australia; and stygobitic members of the genera *Bidessodes* Regimbart (Bidessini) and *Copelatus* Erichson (Copelatinae) have been discovered as well as numerous new species of the Hydroporine genus *Nirripirti* Watts & Humphreys, previously known from only one species. The *Copelatus* is the subject of a separate paper that also includes preliminary results of a study of the phylogenetic relationships between it and other Australian *Copelatus* using DNA sequence data (Balke et al 2003). A similar but separate study has been undertaken on the relationships of the Hydroporine stygobites and potential above-ground relatives (Cooper et al 2002). This study confirms the close relationship between the stygobitic bidessine genera *Nirridessus* Watts & Humphreys and *Tjirtudessus* Watts & Humphreys and the surface genera *Limbodessus* Guignot and *Boongurrus* Larson, as well as the Australian species of *Liodessus* Guignot. The study also suggests that the Hydroporine *Nirripirti* is close to *Paroster* Sharp as we previously suggested (Watts & Humphreys 2001). This latter placement has been confirmed by Ignacio Ribera (pers. comm.), who included *Nirripirti hinzeae* Watts & Humphreys in a worldwide study of relationships within the Dytiscidae using sequence data from the mitochondrial genome.

Based on sequence data, two of the new Bidessine species showed little genetic

relationship with either *Tjirtudessus* or *Nirridessus* but grouped somewhat distantly with Australian species of *Bidessodes* Regimbart. Mainly on this evidence they are described here as members of that genus, pending further study and additional specimens and possibly species.

The sequence data is unequivocal in saying what was becoming increasingly apparent morphologically: that any distinction between *Tjirtudessus* and *Nirridessus* is artificial and appears to be based primarily on size. Equally unequivocal is the paraphyletic nature of both these genera together with the Australian *Liodessus* species. The sequence data also includes the genera *Boongurrus* and *Limbodessus* in a very bushy phylogenetic tree. *Allodessus* Guignot is only a little more distant. It is clear that the current taxonomy of this group of genera is untenable. To sort it out will require considerable study, beyond the scope of this paper. We have, however, decided that the existing evidence is too strong not to synonymise the genera *Tjirtudessus* and *Nirridessus,* which we formally do here, *Tjirtudessus* having page priority. We do this in the knowledge that in all probability they will be further synonymised with some or all of the above-ground genera mentioned previously (M. Balke & I. Ribera, pers. comm.).

The bulk of the new species are evenly split numerically between the Bidessine *Tjirtudessus* and the Hydroporine *Nirripirti.* Geographically the two genera appear to have generally different distributions: *Tjirtudessus* more southern and *Nirripirti* more northern. The two *Bidessodes* species are known only from the northern Gascoyne region and will probably also prove to have a northern distribution, as do their above-ground congeners.

As in previous years, the collection includes additional species, known only from either female specimens or partial specimens, and larval specimens of both *Tjirtudessus* and *Nirripirt.* However, these are not reported on at this time, primarily due to lack of suitable material or, in the case of larvae, no firm association with adults. The latter is currently under way utilising genetic typing.

As for the aquifer systems reported in our earlier papers, numerous specimens of Crustacea (bathynellids, harpacticoid and cyclopoid copepods, ostracods and oniscid isopods) and some Oligochaeta and Hydracarina were collected. In addition, some sites in the Northern Territory yielded a diversity of strongly stygomorphic Hydrobiidae (Gastropoda). As before, the beetles and larger stygofauna were restricted to aquifers in areas of calcrete, as the stygofauna is largely found in the northern parts of the western shield (Poore & Humphreys 1998, submitted; Humphreys 1999a, 2001). As reported in our previous paper (Watts & Humphreys 2001), stygofauna were present both in narrow bore-holes drilled for geological purposes, water pumping or aquifer assessment, and in wide hand-dug wells established for pastoral purposes. The watertable in calcrete is often only 2–3 m below the surface; it is frequently exposed by calcrete quarries used for the purpose of road making or mineral processing, which, being left unfenced, are readily grossly contaminated by stock.

Materials and Methods

The collection methods and measurements of physicochemical parameters in the water largely follow those used previously (Watts & Humphreys 2000). However, the use of a Horiba U22 multiparameter instrument in conjunction with previous methods permitted vertical profiles of the physicochemical conditions down some boreholes. Nitrate and Fe^{++} were recorded using test strips in the field (Merck: respectively Merckoquant Nitrate Test 1.0020.001 and Merckoquant Iron Test 1.10004.0001). On analysis, mid-point values were used if a range had been recorded. Hydrogen sulphide was measured, when its odour indicated its presence, using a test kit (Chemetrics: CHEMets sulphide R-9510, range 0–1 and 1–10 ppm).

Abbreviations used:

BES	Prefix for field numbers, WAM Biospeleology.
SAMA	South Australian Museum, Adelaide.
WAM	Western Australian Museum, Perth.
RN	Prefix of water bore and well numbers, Water Resources Division, Department of Lands Planning and Environment in the Northern Territory.
NTM	Northern Territory Museum, Darwin.

Systematics

Key to Australian species of stygobitic Dytiscidae

1. — Body length approximately 1.0 mm; legs stout, without swimming-hairs on fore- and mid-legs ..... *Kintingka kurutjutu* Watts and Humphreys

— Body length > 1.0 mm; legs normal, all with swimming-hairs 2

2 (1) — Parameres one-segmented; metatibia approximately the same width throughout; without pronotal plicae; (Hydroporini). 28

— Parameres two-segmented; metatibia narrow at base then strongly expanding towards apex; usually with pronotal plicae ..... (Bidessini) 2

3 (2) — Mesofemur with spines on hind edge approximately the same strength as those on mesotrochanter; length > 3.0 mm 23

— Mesofemur with spines on hind edge much more robust than those on mesotrochanter; length 1.4–3.6 mm 4

4 (3) — Lacking sutural line between abdominal sternites 1 and 2; length 3.2–3.6 mm ..... *Tjirtudessus sweetwatersensis* sp. nov.

— Abdominal sternites 1 and 2 separated by sutural line, at least in inner portion; length 1.3 –3.2 mm 5

5 (4) — Pronotal plicae strong, well marked, excavated on inside 6

— Pronotal plicae weak, difficult to trace, may be absent, not excavated on inside 10

6 (5) — Mesosternum with posterior portion triangular in midline 7

— Mesosternum with posterior portion rounded in midline 8

7 (6) — Prosternal process rounded at tip; tip of metatrochanter pointed; lobe on apical segment of paramere short .... *Tjirtudessus morgani* (Watts and Humphreys)

— Prosternal process pointed at tip; apex of metatrochanter rounded (Fig. 5); lobe on apical portion of paramere long (Fig. 3) ....*Tjirtudessus bialveus* sp. nov.

8 (7) — Head broad, deflexed; metatrochanter round (Fig. 35); setae on mesofemur long (Fig. 34) .... *Tjirtudessus silus* sp. nov.

— With none of above characters 9

9 (8) — Metatarsi with combined length of segments 1 and 2 > combined length of segments 3 to 5; eye remnant present; paramere with long apical lobe .... *Tjirtudessus pulpa* (Watts and Humphreys)

— Metatarsi with combined length of segments 1 and 2 approximately equal to combined length of segments 3 to 5 (Fig. 6); eye remnant reduced to single short suture; paramere with small apical lobe (Fig. 9) .... *Tjirtudessus cunyuensis* sp. nov.

10 (5) — Elytron with row of large punctures adjacent to suture 22

— Elytron without sutural punctures, other than a few weak ones near base 11

11 (10) — Eye remnant reduced to a small oval or triangular structure 19

— Eye remnant reduced to single short suture 12

12 (11) — Mesofemur with six to seven spines on hind edge in basal half 13

— Mesofemur with two to four spines on hind edge in basal half 15

13 (12) — Protibia thick; protarsi moderately expanded, mesotarsi less so; mesotibia slightly angular .... *Bidessodes gutteridgei* sp. nov.

— Protibia thin; protarsi and mesotarsi approximately the same size; mesotibia not angular 14

14 (13) — Lobe of paramere as wide as rest of apical segment, flat on top, expanded slightly at tip ..... *Tjirtudessus masonensis* (Watts and Humphreys)

— Lobe of paramere shorter than rest of apical segment, rounded on top, tip pointed (Fig. 51) ..... *Tjirtudessus yuinmeryensis* sp. nov.

15 (12) — Mesofemur with four spines near base; segments 2 and 3 of antenna similar in length, segment 11 approximately 1.5x segment 10 in length; length > 2.0 mm ..... *Tjirtudessus cueensis* (Watts and Humphreys)

— Mesofemur with two to three strong spines on hind edge near base; segment 2 of antenna large and oval, segment 3 much smaller and thinner than segment 2, segment 11 approaching 2x length of segment 10; length < 2 mm 16

16 (15) — Mesofemur with two strong spines on hind edge near base; apical segment of paramere with two finger-like projections ..... *Tjirtudessus pinnaclesensis* (Watts and Humphreys)

— Mesofemur with three strong spines on hind edge near base; apical segment of paramere with one finger-like projection 17

17 (16) — Metafemur with three spines grouped together near base .... *Tjirtudessus fridaywellensis* (Watts and Humphreys)

— Metafemur with two spines near base and one more distant 18

18 (17) — Pro- and mesotibia club-shaped; antenna with middle segments enlarged a little on inside ..... *Tjirtudessus hinkleri* (Watts and Humphreys)

— Pro- and mesotibia elongate/triangular in shape; middle segments of antenna virtually symmetrical ..... *Tjirtudessus karalundiensis* sp. nov.

19 (11) — Pronotum not constricted at base (Fig. 48); prosternal process reaching or almost reaching mesosternum; 1.4 mm long .... *Tjirtudessus wilunaensis* sp. nov.

— Pronotum moderately constricted at base (Fig. 18); pronotal process not reaching mesosternum; >1.8 mm long 20

20 (19) — Mesofemur with six spines close to base on hind edge ..... *Tjirtudessus bigbellensis* (Watts and Humphreys)

— Mesofemur with three to six spines spread out along basal half of hind edge (Fig. 16) 21

21 (20) — Suture line between sternites 1 and 2 well marked; medial lobe of aedeagus parallel-sided, apex not upturned .... *Tjirtudessus challaensis* (Watts and Humphreys)

— Suture lines between ventrites 1 and 2 weak, usually obsolete in lateral half; medial lobe of aedeagus distinctly narrower in middle, apex upturned (Fig. 13) .... *Tjirtudessus jundeeensis* sp. nov.

22 (10) — Distinct oval eye remnant present .... *Tjirtudessus windarraensis* (Watts and Humphreys)

— Eye remnant reduced to single short suture ..... *Tjirtudessus lapostaae* (Watts and Humphreys)

23 (3) — Mesofemur with spines on hind edge arranged in two comb-like rows along hind edge from base to apex; mesotibia thin, curved .... *B. limestoneensis* sp. nov.

— Mesofemur spines on hind edge spaced out, not dense and comb-like; mesotibia straight 24

24 (23) — Pro- and mesotarsi with segment 1 much more expanded than other segments 25

— Pro- and mesotarsi with segment 1 only moderately expanded compared to other segments 26

25 (24) — Antenna with segments 8 to 11 noticeably thinner than others, segment 3 longer than segment 2 .... *Tjirtudessus magnificus* Watts and Humphreys

— Antenna with segments 8 to 11 not noticeably thinner than others, segment 3 same length as segment 2 (Fig. 30) .. *Tjirtudessus macrotarsus*. sp. nov.

26 (25) — Pronotum a little narrower than elytra; length 3.5–4.8 mm 27

— Pronotum wider than elytra; length 3.2–3.5 mm ..... *Tjirtudessus eberhardi* Watts and Humphreys

27 (26) — Metatrochanters rounded at tip; central lobe of aedeagus straight, tip pointed; with small eye remnant.... *Tjirtudessus raesideensis* Watts and Humphreys

— Metatrochanters pointed at tip; central lobe of aedeagus twisted, tip knobbed; without eye remnant .... *Tjirtudessus hahni* Watts and Humphreys

28 (27) — From the Northern Territory 29

— From Western Australia 33

29 (28) — Head short, very broad, strongly deflexed (Fig. 96); pronotum strongly narrowed at base (Fig. 96); pronotal process anvil-shaped .... *Nirripirti macrocephalus* sp. nov.

— Head variably shaped, not deflexed, base of pronotum variable, pronotal process 'normally' shaped 30

30 (29) — Protarsi with segment 3 not bilobed; pronotum not constricted at base (Fig. 126); antenna thin, segments 1 and 2

subequal .... *Nirripirti pentameres* sp. nov.

— Protarsi with segment 3 bilobed; pronotum weakly to moderately constricted at base; antenna thick, segment 2 much broader than segment 1 31

31 (30) — 1.8 mm long; body well chitinised .. .. *Nirripirti napperbyensis* sp. nov.

— 1.2–1.6 mm long; body weakly chitinised 32

32 (31) — 1.2 mm long; body only slightly constricted at junction of pronotum and elytra (Fig. 150) .... *N. wedgeensis* sp. nov.

— 1.5 mm long; body quite strongly constricted at junction of pronotum and elytra (Fig. 120) .... *Nirripirti newhavenensis* sp. nov.

33 (28) — Antenna with segment 2 larger and more oval than segment 1; < 2.5 mm long 38

— Antenna with segment 2 more or less the same shape as segment 1 or smaller; > 2.5 mm long 34

34 (33) — Elytron in ventral aspect, with visible portion broad except close to apex .. .. *Nirripirti stegastos* sp. nov.

— Elytron in ventral aspect, with visible portion narrow except in basal quarter 35

35 (34) — Metasternal plate parallel-sided; eight to ten metafemur spines, closely placed, very strong (Fig. 76); metatrochanter long and thin about 4x as long as wide (Fig. 77) .... *Nirripirti fortisspina* sp. nov.

— Metasternal plate narrowing towards rear; four to eight metafemur spines, weak to moderately strong; metatrochanter moderately elongate 2 to 2.5x as long as wide 36

36 (35) — Metasternal plate without wings ....*Nirripirti plutonicensis* sp. nov.

— Metasternal wings obvious but short 37

37 (36) — Metafemur with moderately strong spines; metacoxal plate nearly reaching mesocoxae ..... *Nirripirti hinzeae* Watts and Humphreys

— Metafemur with thin spines (Fig. 70); metacoxal plate at least the width of metafemur from mesocoxae..... ..... *Nirripirti darlotensis* sp. nov.

38 (33) — Elytron with shoulder flared outwards (Fig. 84); tip of metatrochanter pointed (Fig. 83).....*Nirripirti hamoni* sp. nov.

— Elytron with shoulder not flared; metatrochanter squat, tip rounded (Fig. 107) 39

39 (38) — Eye remnant absent; metatrochanters large, squat (Fig. 107); hind legs stout; metasternal plate V-shaped; 1.2 mm long .... *Nirridessus milgunensis* sp. nov.

— Eye remnant represented by a short suture at side of head; metatrochanters elongate; hind legs elongate; metasternal plate U-shaped; 1.5–2.3 mm long 40

40 (39) — Head narrower than base of pronotum, body boat-shaped (Fig. 138) 41

— Head broader than base of pronotum, body not boat-shaped (Fig. 102) .... *Nirripirti melroseensis* sp. nov.

41 (40) — 2.1–2.3 mm long; metatrochanter with tip sharply pointed (Fig. 137) .... *Nirripirti skaphites* sp. nov.

— 1.5–1.9 mm long; metatrochanter with tip rounded (Fig. 89) .... *Nirripirti killaraensis* sp. nov.

The following species descriptions are grouped in alphabetical order under genus, which are placed in the order *Tjirtudessus, Bidessodes, Nirripirti.*

Tjirtudessus Watts & Humphreys, 1999

Tjirtudessus bialveus sp. nov.

Types

Holotype: m: 'BES 8118, Cunyu Station, Site 289, mineral exploration bore, 25°46'51"S 120°06'27"E, 24/8/2001, coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM. 32866. Slide mounted.

Paratypes: 17; 9, as for holotype, 6 WAM 32867–32872, 3 SAMA; 3, as for holotype except 'BES 8115', SAMA; 2, as for holotype except 'BES 8601, site 288', WAM 32873–32874; 3, as for holotype except 'BES 8602, site 288', SAMA.

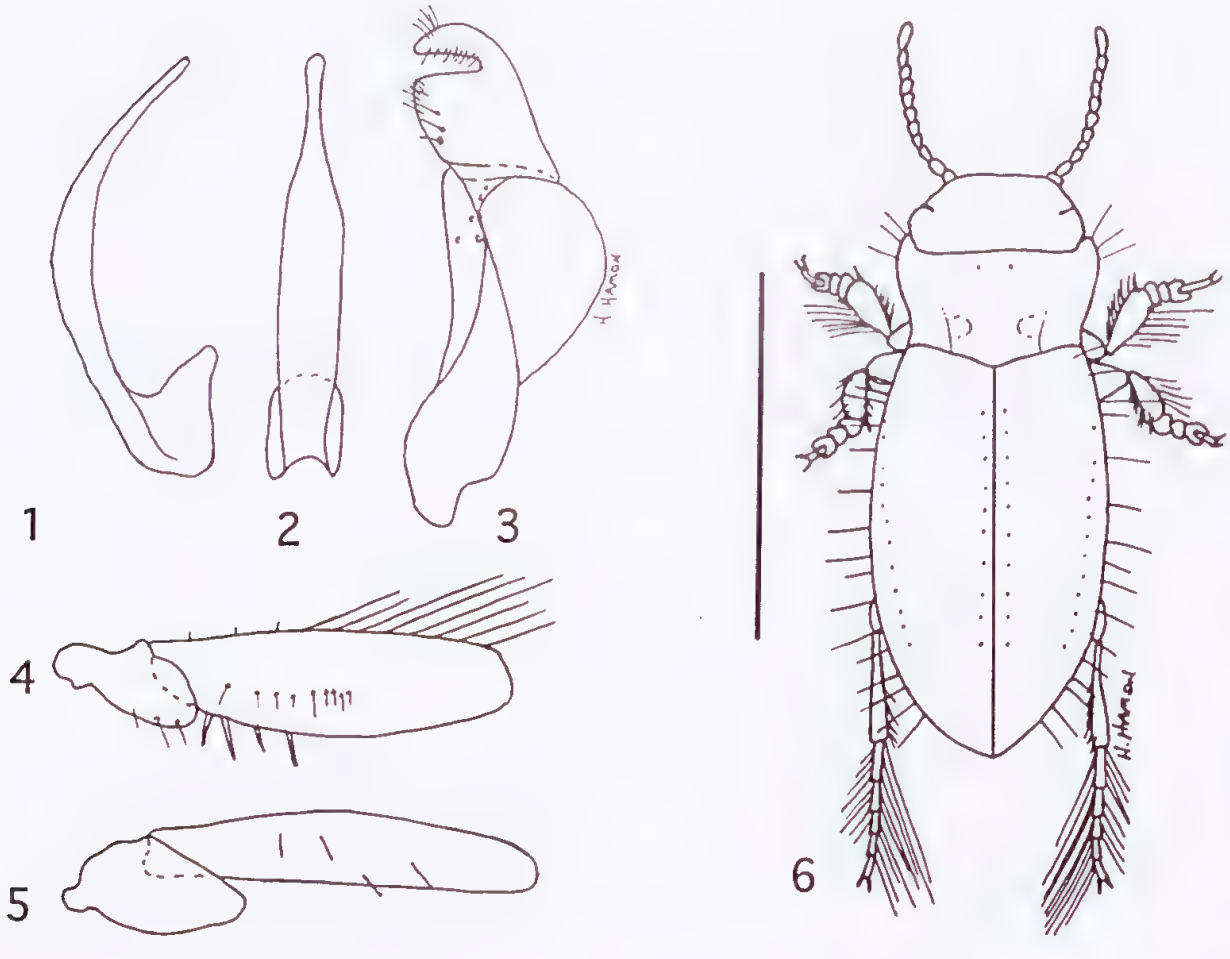
Description (number examined, 18) Figs 1–7

Habitus. Length 1.4–1.9 mm; elongate, relatively flat, weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about one-quarter length of elytron.

Head. A little narrower than elytra; smooth, reticulation strong, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to short dark suture. Antenna stout, basal segment cylindrical, segment 2 oval, segment 3 shorter and narrower and narrowing towards base, segments 4 to 10 subequal, segment 11 about twice as long as segment 10. Maxillary palpus relatively stout, segment 4 about as long as segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. Almost as wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute; smooth, with sparse, very weak punctures and a row of stronger punctures along front margin; basal plicae strongly marked, curved, reaching to about halfway along pronotum, deeply excavated inwards; with row of long setae laterally, denser towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, strongly reticulate, evenly but sparsely covered with small punctures each with a small seta, row of widely spaced larger punctures close to inner edge; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with a few setiferous micropunctures towards apex and sides. Epipleuron undifferentiated, that part of elytron visible ventrally broad in anterior fifth, then rapidly narrowing to be virtually absent along rest of elytron.



FIGURES 1–6. *Tjirtudessus bialveus*: **1**, lateral view of central lobe of aedeagus; **2**, ditto dorsal view; **3**, paramere; **4**, mesotrochanter and mesofemur; **5** metatrochanter and metafemur; **6**, dorsal view. Scale bar represents 1 mm (habitus only).

Ventral surface. Prosternal process relatively broad, strongly narrowed between coxae, almost reaching mesothorax, apical half narrow, almost parallel-sided, tip with long elongate point, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae almost in contact at midline. Metasternum sharply triangular in front in midline; wings short, narrow; triangular in midline behind not reaching halfway to metacoxae. Metacoxal plates large, metacoxal lines weak, moderately widely spaced, reaching to about halfway to metasternum, evenly diverging; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae; strongly reticulate.

Legs. Protibia relatively broad, inner edge straight, outer edge bowed, widest near apex where it is about four times its basal width; protarsi moderately expanded, segment 1 round, segment 2 shorter, segment 3 as long as 1 but a bit narrower and deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about 1.5 times length of segment 3, segments 1 to 3 with covering of adhesive setae; claws short and simple. Mesotrochanter elongate with row of setae on inner edge; mesofemur with two spines close together at base and one more distant along hind edge in basal half (Fig. 4); mesotarsi much less expanded than protarsi. Metatrochanter elongate, tip rounded, well separated from femur (Fig. 5); metafemur elongate, lacking spines; metatibia curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 longer than 4, segments 1 and 2 in combination about as long as segments 3 to 5; claws weak.

Male. Pro- and mesotarsi slightly stouter. Median lobe of aedeagus narrow, tip bluntly pointed; paramere broad, apical segment with long, narrow, apical portion well separated from rest of segment (Figs 1–3).

Etymology

Latin. 'Bi' – two, 'alveus' – pit, excavation; alluding to the two very strongly excavated areas on the pronotum.

Remarks

A relatively small species with strong reticulation and deep excavations inwards from the pronotal plicae. These pits partially undercut the plicae and on their inner edge are ridged for a short distance. The purpose of these structures—which are much deeper than we have seen on any other Dytiscid—are unknown. They do not seem to have any sensory structures associated with them. They are often partially filled with a gritty material.

Tjirtudessus cunyuensis sp. nov.

Types

Holotype: m. 'BES 8156, Cunyu Station, Sweetwaters Well, 25°35'28"S 120°22'21"E, 23/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32875.

Paratypes 3: 1, as for holotype, WAM 32876; 2, as for holotype except '8107', SAMA.

Description (number examined, 4) Figs 7–12

Habitus. Length 1.3 mm; narrowly oval, relatively flat, weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about one-half length of elytron.

Head. Much narrower than elytra; smooth, reticulation strong, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to a short suture. Antenna stout, basal segment cylindrical, segment 2 oval, segment 3 smaller and narrower, segment 4 slightly smaller than 3, segments 5 to 10 subequal, segment 11 about 1.5 times length of segment 10. Maxillary palpus stout, segment 4 about as long as segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. As wide as elytra; anteriolateral angles projecting strongly forward; base moderately narrowed, posterolateral angles obtuse; smooth, with sparse, very weak punctures each with a short seta and a row of stronger punctures along front margin; basal plicae moderately marked, slightly curved, reaching to about halfway along pronotum, quite strongly excavated inwards; with row of long setae laterally, denser towards front.

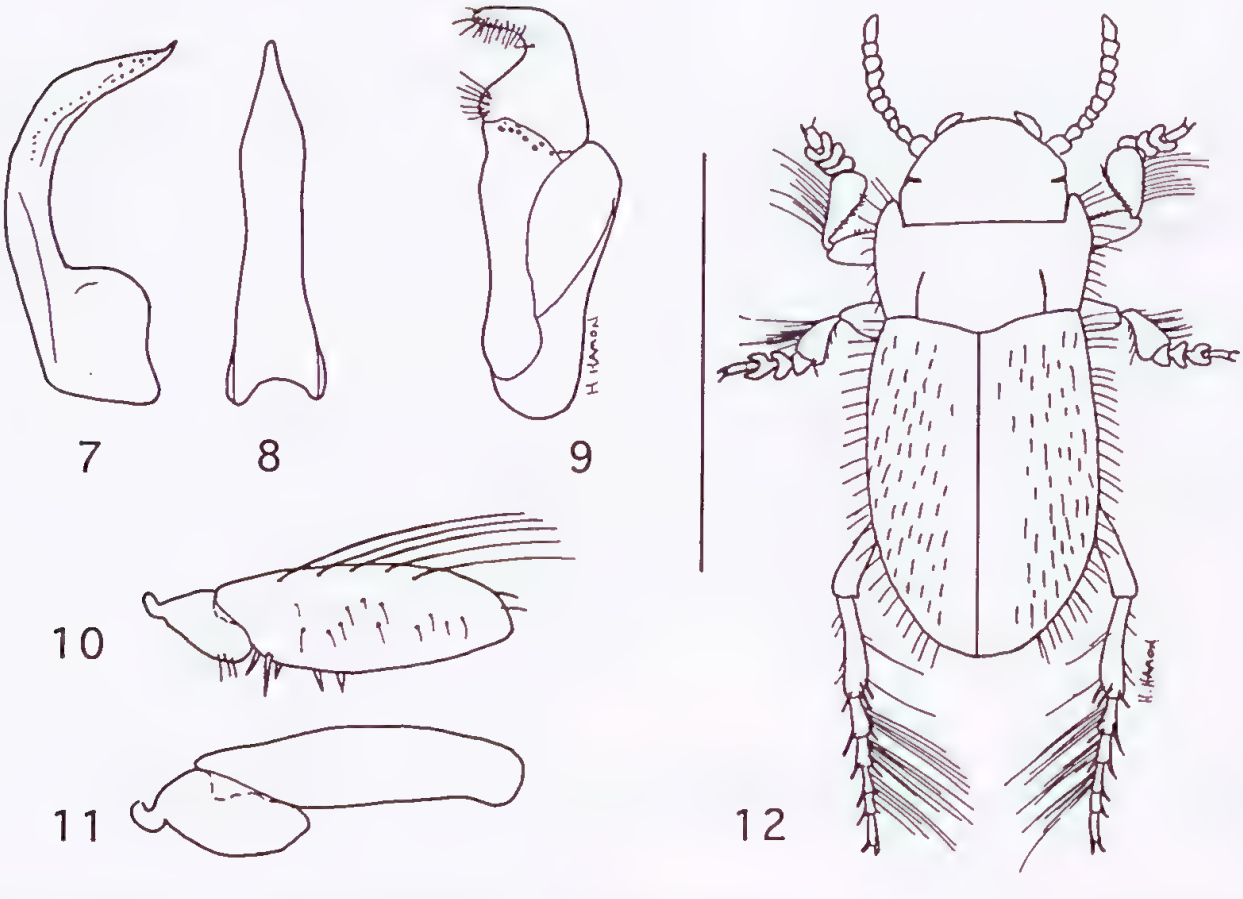
Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, moderately covered with small punctures each with a short setae, a short row of larger punctures close to inner edge on disc; a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with numerous setiferous micropunctures towards apex and near suture. Epipleuron undifferentiated, that

part of elytron visible ventrally narrow except close to base.

Ventral surface. Prosternal process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half narrow, almost parallel-sided, weakly pointed at apex, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply triangular in front in midline; wings very narrow; broadly rounded in midline behind; not quite reaching halfway to metacoxae. Metacoxal plates large, metacoxal lines weak, widely spaced, almost parallel, reaching nearly to metasternum; a few small setae-bearing punctures towards midline; reticulation moderate, meshes uneven; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively broad, inner and outer edges straight, widest past apex where it is about four times its basal width; protarsi expanded, segment 1 broad, segment 2 as broad as and about one-third length of segment 1, segment 3 as long as 1 and as broad, very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with covering of adhesive setae; claws short and simple. Mesotrochanter elongate with row of setae on inner edge; mesofemur with row of four to five relatively weak spines unevenly spaced along hind edge in basal half (Fig. 10); mesotarsi less expanded than protarsi. Metatrochanter tip pointed, weakly separated from femur at tip (Fig. 11); metafemur relatively broad, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

Male. Median lobe of aedeagus relatively broad, tip sharply pointed; paramere broad, apical segment narrow, apical portion well separated from rest of segment (Figs 7–9).



FIGURES 7–12. *Tjirtudessus cunyuensis*: **7**, lateral view of central lobe of aedeagus; **8**, ditto dorsal view; **9**, paramere; **10**, mesotrochanter and mesofemur; **11** metatrochanter and metafemur; **12**, dorsal view. Scale bar represents 1 mm (habitus only).

Etymology
Named after the pastoral station on which it was collected.

Remarks
A relatively small species with stout antennae and legs and well-marked pronotal plicae. Resembles *T. pulpa,* from which it differs in lack of oval eye remnant and short apical lobe to the paramere.

Tjirtudessus jundeeensis sp. nov.

Types
Holotype: m. "BES 6475, Jundee Station, bore at Jundee Homestead, 26°21'12"S; 120°38'31"E, 11/5/2001, col. W.F. Humphreys, C.H.S. Watts & S. Cooper', WAM 32877. Slide mounted.

Paratypes: 27; 1, as for holotype, WAM 32878; 17, 'BES 6581, Jundee Station. bore JSP 6, South Hill Well BF, Jundee Mine, 26°16'58"S 120°40'37"E, 11/5/2001, col. W.F. Humphreys, C.H.S. Watts & S. Cooper', 2 WAM 32879–32880, 15 SAMA; 1, as for holotype except 'BES 6582' and 'JE149', WAM 32881; 1, as for holotype except 'BES 6590' and 'JE124', WAM 32882; 3, as for holotype except 'BES 6594' and 'JE112', 3 WAM 32883–32885; 3, as for holotype except 'BES 6597' and 'JE150', 2 WAM 32886–32887, 1 SAMA; 2, as for holotype except 'BES 6603' and 'JE125', WAM 32888–32889.

Description (number examined, 28) Figs 13–18
Habitus. Length 2.3–2.6 mm; relatively flat, moderately constricted at base of pronotum; uniformly very light testaceous; hindwing reduced, about three-quarters length of elytron.

Head. Narrower than elytra; smooth, reticulation very weak, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to narrowly oval structure. Antenna relatively stout, segments 1 and 2 cylindrical, segment 3 slightly shorter than segment 2 narrowing towards base, segments 4 to 10 subequal but becoming progressively slightly broader, segment 11 1.5 times longer and slightly thinner than segment 10. Maxillary palpus moderately elongate, segment 4 a little shorter than segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

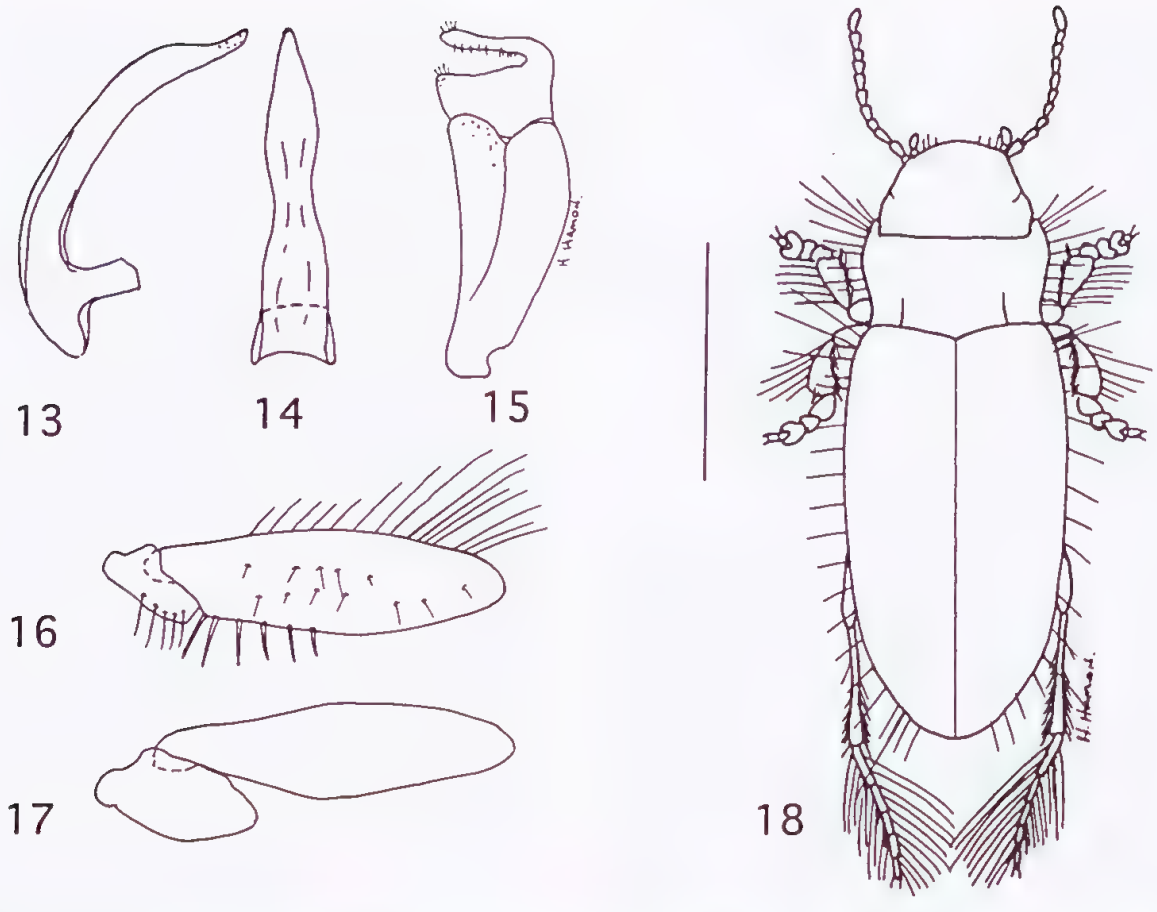
Pronotum. As wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute; smooth with sparse, very weak punctures and a row of stronger punctures along front margin; basal plicae weakly marked, converging slightly towards front, reaching to about halfway along pronotum; with row of long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges; elongate, almost parallel-sided, smooth, sparsely covered with very small punctures; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides; underside with a few scattered setiferous micropunctures towards apex. Epipleuron weakly differentiated, that part of elytron visible ventrally moderately broad in anterior fifth, thin over rest of elytron.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half relatively broad, almost parallel-sided, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly triangular in front in midline; wings very narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines obsolete; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct towards midline, becoming indistinct laterally, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively narrow, triangular, widest at apex where it is about 2.5 times its basal width; protarsi moderately expanded, segment 1 as wide as long, segment 2 about as wide and about one-half length of segment 1, segment 3 as long and wide as first, very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with very dense covering of adhesive setae; claws one-half length of segment 5. Mesotrochanter elongate with a few fine setae on inner edge; mesofemur with row of five to six moderately strong setae along hind edge in basal half (Fig. 16); mesotarsi similar to protarsi. Metatrochanter tip rounded, well separated from metafemur (Fig. 17); metafemur thin, elongate, lacking spines; metatibia thin, strongly curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 longer than segment 4, in combination segments 1 and 2 about as long as others; claws equal, weak.

Male. Little external difference between median



FIGURES 13–18. *Tjirtudessus jundeeensis*: **13**, lateral view of central lobe of aedeagus; **14**, ditto dorsal view; **15**, paramere; **16**, mesotrochanter and mesofemur; **17** metatrochanter and metafemur; **18**, dorsal view. Scale bar represents 1 mm (habitus only).

lobe of aedeagus varying slightly in width along shaft, narrowing towards apex, bluntly pointed; parameres broad, apical segment relatively broad, short, with long, narrow, apical lobe well separated from rest of segment (Figs 13–15).

Etymology

Named after the pastoral station on which it was collected.

Remarks

A moderate sized, narrowly elongate, weakly chitinised species with the tip of the metatrochanter well separated from the femur, and weak pronotal plicae. Morphologically close to *T. challaensis* but with the suture line between first and second ventrites much less obvious and the apical lobe of the paramere well separated from the rest of the segment.

Tjirtudessus karalundiensis sp. nov.

Types

Holotype: m: 'Karalundi, unlined well, 26°08'S 118°41'E, 28/5/2001. Col. C.H.S.& G.A Watts'. Field number 339-1. WAM 32890. Slide mounted.

Paratypes: 14, as for holotype 5, WAM 32891–32895, 9 SAMA.

Description (number examined, 15) Figs 19–24.

Habitus. Length 1.3–1.4 mm; relatively flat, moderately constricted at junction of pronotum/elytra; elytra relatively broad, uniformly light testaceous; hindwing reduced, about length of elytron.

Head. Narrower than elytra; smooth, reticulation moderate, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to short suture. Antenna relatively stout, segment 1 cylindrical, segment 2 oval, segment 3 about one-half length segment 2 and two-thirds width, narrowing towards base, segment 4 bit shorter and narrower than segment 3, segments 5 to 10 subequal and a little wider than 3 and 4, segment 11 about twice length of segment 10. Maxillary palpus elongate, segment 4 a little shorter than

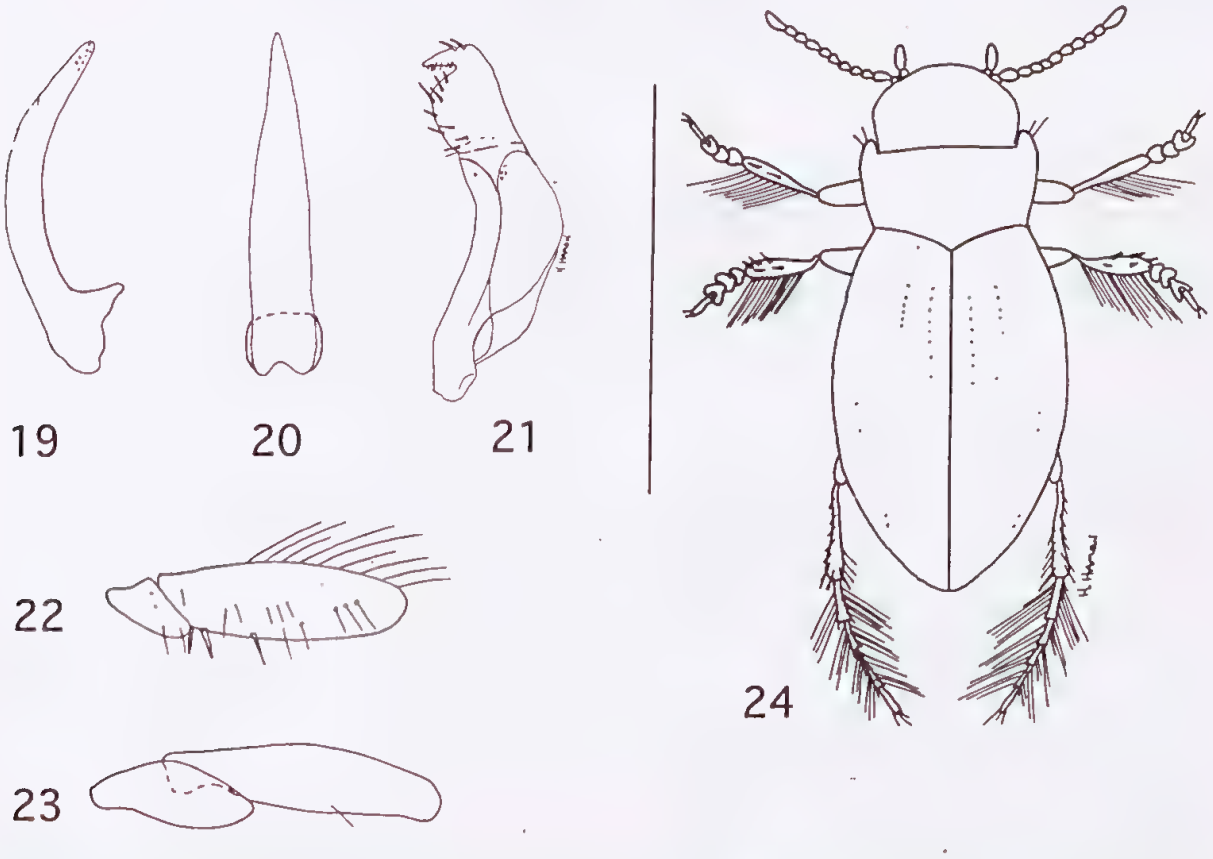
segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. Narrower than elytra; anteriolateral angles projecting strongly forward; base moderately constricted, posterolateral angles acute; smooth, moderately reticulate, with sparse, very weak punctures and a row of stronger punctures along front margin, sparse covering of short setae; basal plicae absent, straight; with row of long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges; oval, widest in middle, smooth, moderately reticulate, moderately densely covered with short setae, sparsely covered with very small punctures, row of widely spaced larger punctures close to inner edge; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with numerous setiferous micropunctures towards apex. Epipleuron only weakly differentiated; that portion of elytron visible ventrally narrow in anterior fifth, virtually absent along rest of elytron.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half relatively broad, almost parallel-sided, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly triangular in front in midline; wings very narrow; posterior portion relatively narrow, rounded at apex. Metacoxal plates large, heart-shaped in combination, metacoxal lines absent, surface reticulate, a few small setae-bearing punctures towards midline; closely adpressed to abdominal ventrite 1. Ventrites 1 and 2 fused, sutural lines distinct, ventrites 3 to 5 mobile, moderately rugose, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia triangular, widest at apex where it is about three times its basal width; protarsi moderately expanded, segment 1 about twice as long as wide, segment 2 a little broader and about one-half length of segment 1, segment 3 as long as first slightly broader, very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about twice length of segment 3, segments 1 to 3 with adhesive setae; claws short and simple. Mesotrochanter elongate with a few setae on inner edge; mesofemur with row of three relatively



FIGURES 19–24. *Tjirtudessus karalundiensis*: **19**, lateral view of central lobe of aedeagus; **20**, ditto dorsal view; **21**, paramere; **22**, mesotrochanter and mesofemur; **23** metatrochanter and metafemur; **24**, dorsal view. Scale bar represents 1 mm (habitus only).

strong setae along hind edge in basal half (Fig. 22); mesotarsi about one-half breadth of protarsi. Metatrochanter tip pointed, (Fig. 23); metafemur elongate, lacking spines; metatibia moderately curved, widening towards apex; metatarsi elongate, segment 1 longest, other segments approximately equal in length, in combination segments 1 and 2 about as long as others; claws weak.

Male. No external differences between the sexes. Median lobe of aedeagus parallel-sided narrowing towards apex, tip bluntly pointed; paramere broad, apical segment relatively long, with narrow apical lobe moderately separated from rest of segment, about one-half width of segment (Figs 19–21).

Etymology

Named after type locality.

Remarks

A small elongate/oval species moderately constricted at the base of the pronotum and with three stout spines on the mesofemur. It most closely resembles *T. hinkleri,* from which it is most easily separated by the smaller apical lobe on the paramere and the symmetrical rather than slightly asymmetrical middle antennal segments.

Tjirtudessus macrotarsus sp. nov.

Types

Holotype: m: 'BES 8118, Cunyu Station, Site 289, mineral exploration bore, 25°46'51"S 120°06'27"E, 24/8/2001 col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32896. Slide mounted.

Paratypes: 7: 5, as for holotype, 3 WAM 32897–32899, 2 SAMA; 2, as for holytype except 'BES 8115' SAMA.

Description (number examined, 8) Figs 25–30

Habitus. Length 4.2–4.4 mm; elongate, relatively flat, slightly depressed in midline, moderately constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about one-half length of elytron.

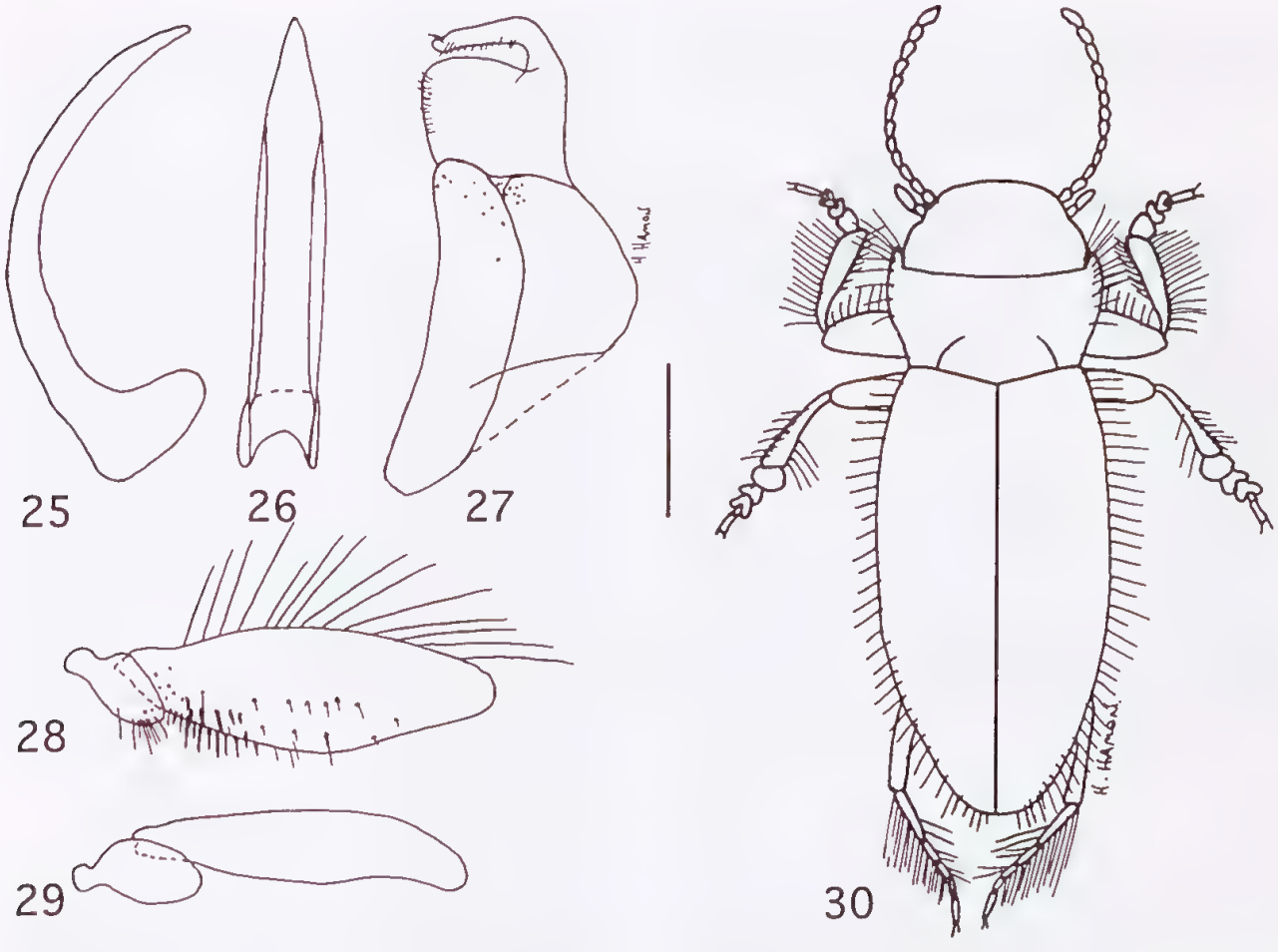
Head. A little narrower than elytra; slightly deflexed; smooth, reticulation weak, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to a short suture. Antenna thin, segments 1 and 2 cylindrical, segments 3 and 4 as long as segment 2 but narrower and slightly narrowing towards base, segments 5 to 9 subequal but becoming progressively shorter, each weakly expanded inwards near apex, segment 10 cylindrical, segment 11 about 1.5 times as long as segment 10. Maxillary palpus elongate, segment 4 a little shorter than segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. Short, almost as wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute, overlapping elytra; smooth, with sparse, very weak punctures and a row of stronger punctures along front margin, reticulation weak; basal plicae moderately marked, straight, short, reaching to about one-third way along pronotum, slightly excavated inwards; with row of long setae laterally, denser towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with very small punctures, a loose row of larger punctures with long setae near centre of each elytron, a moderate number of additional large punctures with long setae, more frequent towards sides. Underside of elytron with a few setiferous micropunctures near base and some on epipleuron near base. Epipleuron very weakly differentiated, that part of elytron visible ventrally broad in anterior fifth, then rapidly narrowing to be virtually absent along rest of elytron.

Ventral surface. Prosternal process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half broad, triangular, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum triangular in front in midline; wings very narrow; broadly rounded in midline behind; reaching well past halfway to metacoxae. Metacoxal plates large, metacoxal lines very weak, relatively close, reaching to about halfway to metasternum, evenly diverging; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct towards midline, becoming indistinct laterally, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae; reticulation very weak.

Legs. Protibia relatively narrow, inner edge straight, outer edge bowed, widest past middle where it is about three times its basal width; protarsi expanded, segment 1 large broadly rounded, segment 2 much narrower, about one-third length of segment 1, segment 3 about half



FIGURES 25–30. *Tjirtudessus macrotarsus*: **25**, lateral view of central lobe of aedeagus; **26**, ditto dorsal view; **27**, paramere; **28**, mesotrochanter and mesofemur; **29** metatrochanter and metafemur; **30**, dorsal view. Scale bar represents 1 mm (habitus only).

as long as segment 1, narrower than segment 2, very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short, relatively robust. Mesotrochanter elongate with row of setae on inner edge; mesofemur with row of 10 to 15 weak spines along hind edge in basal half only slightly stronger than the setae on mesotrochanter (Fig. 28); mesotarsi a little less expanded than protarsi. Metatrochanter relatively small, broadly oval, tip rounded (Fig. 29); metafemur thin, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 much longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

Male. No external differences between the sexes. Median lobe of aedeagus variable in width along shaft, tip bluntly pointed; paramere broad, apical segment relatively large with long, narrow, apical lobe moderately separated from rest of segment (Figs 25–27).

Etymology

Alluding to the large basal tarsal segment of the pro- and mesotarsi.

Remarks

A large narrow species recognised by the large basal segment of the pro- and mesotarsi, thin antenna and broadly oval metatrochanters.

Tjirtudessus silus sp. nov.

Types

Holotype: m: 'BES 8107, Cunyu Station, Sweetwaters Well, 25°35'38"S 120°22'21"E, 23/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32900. Slide mounted.

Paratypes: 25; 10, 'BES 8107, Cunyu Station, Sweetwaters Well, 25°35'38"S 120°22'21"E, 23/8/2001, col. W.F. Humphreys, T. Karanovic &

J.M. Waldock', 5 WAM 32901–32905, 5 SAMA; 4, ditto except 'BES 8156', WAM 32906–32909; 11, ditto except 'BES 8589', 5 WAM 32910–32914, 6 SAMA.

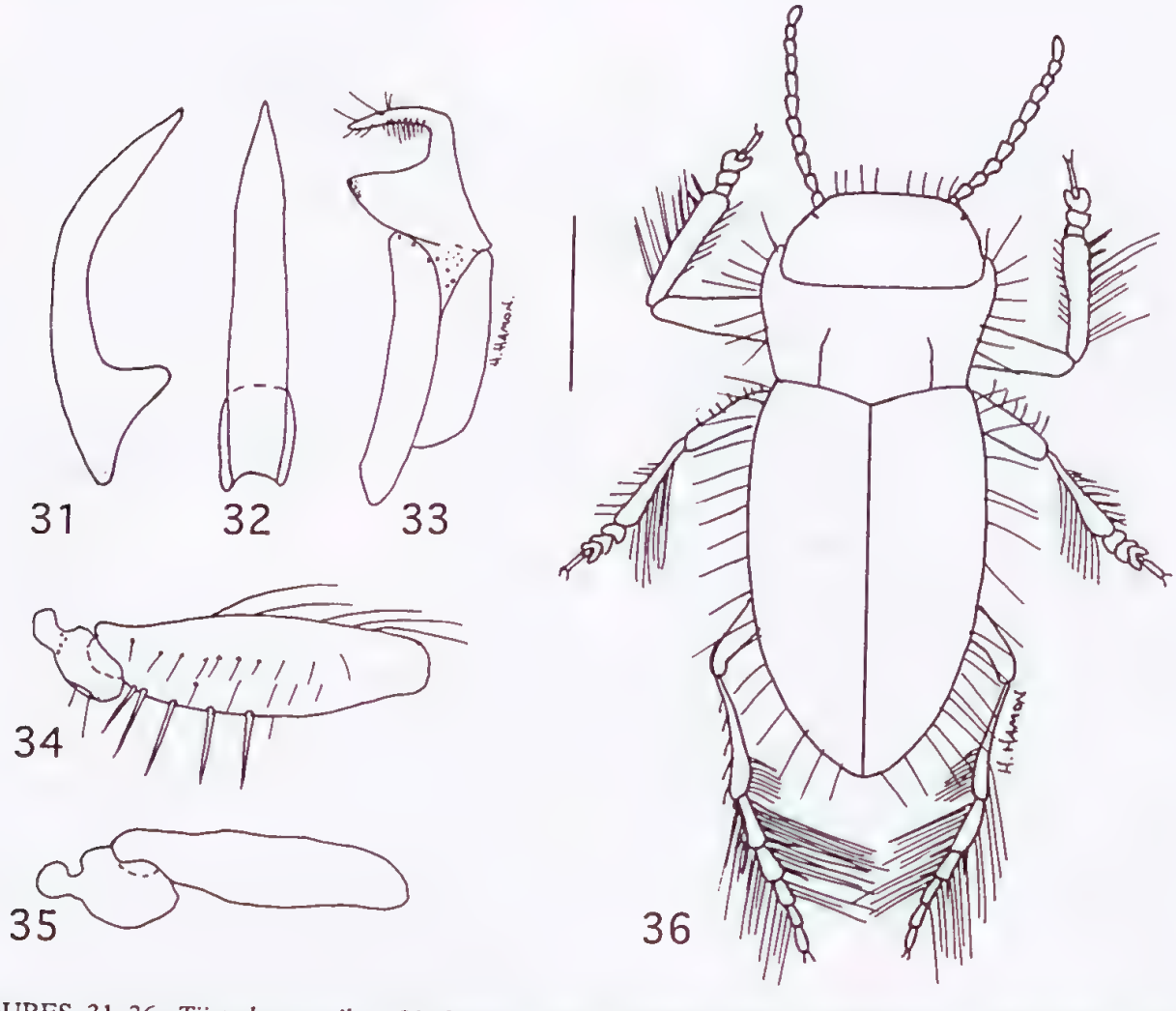
Description (number examined, 26) Figs 31–36

Habitus. Length 1.7–2.1 mm; relatively flat, head somewhat deflexed, weakly constricted at junction of pronotum/elytra; uniformly very light testaceous; hindwing vestigial, about one-third length of elytron.

Head. Short, about as wide as elytra, bulbous in lateral view; smooth, reticulation moderate, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to small triangular or oval structure on ventral surface near edge. Antenna relatively stout, segments 1 and 2 cylindrical, segment 3 shorter than segment 2, segments 4 to 10 subequal, slightly expanded at their apexes on inside, more so on middle segments, segment 11 a bit longer and narrower than segment 10. Maxillary palpus elongate, segment 4 longer than segments 1 to 3 combined, oblique row of long setae on outer side.

Pronotum. Short, as wide as or a bit wider than elytra; anteriolateral angles projecting strongly forward; base weakly constricted, posterolateral angles obtuse; smooth, with sparse, very weak punctures and a row of stronger punctures along front margin; reticulation very weak; basal plicae well marked, slightly sinuate, reaching to about halfway along pronotum, very strongly excavated inwards; with row of long setae laterally, denser towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with very small punctures; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides, underside of elytron with a few setiferous micropunctures towards



FIGURES 31–36. *Tjirtudessus silus*: **31**, lateral view of central lobe of aedeagus; **32**, ditto dorsal view; **33**, paramere; **34**, mesotrochanter and mesofemur; **35**, metatrochanter and metafemur; **36**, dorsal view. Scale bar represents 1 mm (habitus only).

apex and on epipleuron near base. Reticulation weak. Epipleuron undifferentiated, that portion of elytron visible ventrally broad in anterior fifth, then rapidly narrowing to be virtually absent along rest of elytron.

Ventral surface. Prosternal process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half narrow, weakly triangular, tip rounded, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly triangular in front in midline; wings very narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines weak, moderately widely spaced, reaching about halfway to metasternum, subparallel; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines indistinct towards midline, absent laterally, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae; weakly reticulate.

Legs. Protibia elongate, narrow, inner edge straight, outer edge weakly bowed, widest near apex where it is about three times its basal width; protarsi moderately expanded, segment 1 rounded, segment 2 about one-half length of segment 1, segment 3 as long as segment 1 and very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with row of setae on inner edge; mesofemur with row of five to six relatively long spines along hind edge in basal half (Fig. 34); mesotarsi much less expanded than protarsi. Metatrochanter short (Fig. 35); metafemur thin, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, relatively robust, segment 1 longest, segment 5 a little longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

Male. Little external difference between the sexes. Median lobe of aedeagus variable in width along shaft, tip bluntly pointed; paramere broad, apical segment with long, narrow, apical portion well separated from rest of segment (Figs 31–33).

Etymology

Latin. 'Silus' – pug-nosed.

Remarks

A medium sized species easily recognised by its broad pug-nosed head as well as thin legs, round metatrochanters, strong pronotal plicae and long spines on the mesofemurs.

Tjirtudessus sweetwatersensis sp. nov.

Types

Holotype: m: 'BES 8107, Cunyu Station, Sweetwaters Well, 25°35'38"S 120°22'21"E, 23/8/2001, col. W.F. Humphreys, T. Karanovic and J.M. Waldock', WAM 32915. Slide mounted.

Paratypes: 11; 6, as for holotype, SAMA; 2, as for holotype except 'BES 8156', WAM 32916–32917; 3, as for holotype except 'BES 8589', WAM 32918–32920.

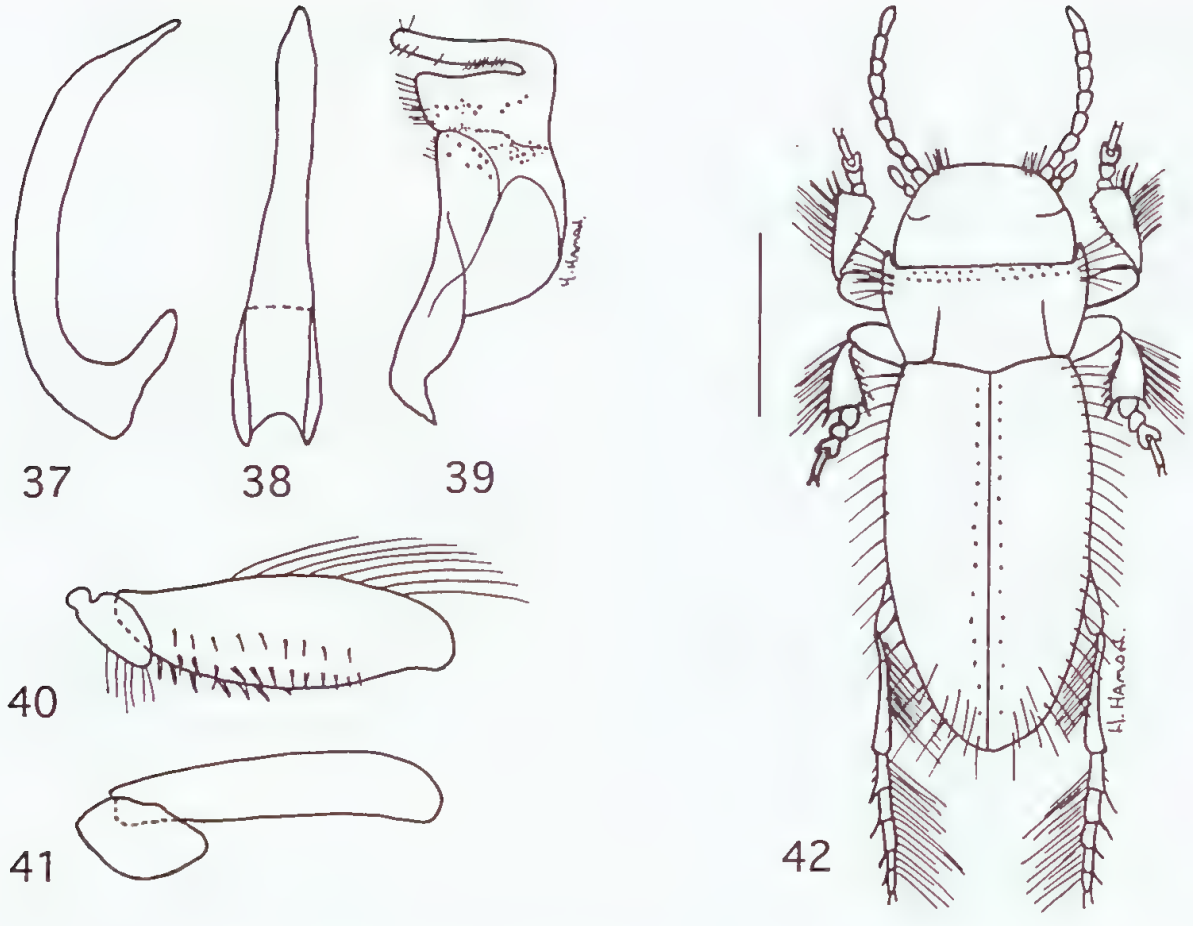
Description (number examined, 12) Figs 37–42

Habitus. Length 3.2–3.6 mm; elongate, relatively flat, moderately constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about one-half length of elytron.

Head. About as wide as elytra; smooth, reticulation moderate, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to narrowly oval structure on underside of head behind antennal bases. Antenna relatively stout, segments 1 and 2 cylindrical, segments 3 and 4 similar, a little shorter than segment 2, segments 5 to 10 subequal, narrower at their bases, segment 11 a bit longer and narrower than segment 10. Maxillary palpus elongate, segment 4 a little shorter than segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. As wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute, slightly overlapping elytra; smooth, with sparse, very weak punctures and a row of stronger punctures along front margin; basal plicae moderately marked, slanted inwards, reaching to about halfway along pronotum, with row of long setae laterally, denser towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with very small punctures, row of widely spaced larger punctures close to inner edge; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with numerous setiferous micropunctures towards apex and near suture. Epipleuron undifferentiated, that part of elytron visible



FIGURES 37–42. *Tjirtudessus sweetwatersensis*: **37**, lateral view of central lobe of aedeagus; **38**, ditto dorsal view; **39**, paramere; **40**, mesotrochanter and mesofemur; **41**, metatrochanter and metafemur; **42**, dorsal view. Scale bar represents 1 mm (habitus only).

ventrally quite broad in anterior quarter, virtually absent along rest of elytra.

Ventral surface. Prosternal process rather narrow, strongly narrowed between coxae, not reaching mesothorax, apical half almost parallel-sided, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum triangular in front in midline; wings very narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines weak, moderately widely spaced, reaching to about halfway to metasternum, almost parallel; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines absent, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae; moderately reticulate.

Legs. Protibia relatively elongate, inner edge straight, outer edge bowed, widest past middle where it is about three times its basal width; protarsi weakly expanded, segment 1 broad, segment 2 about one-third length of segment 1, segment 3 a little longer than segment 2 and deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about twice length of segment 3, segments 1 to 3 with covering of adhesive setae; claws short and simple. Mesotrochanter elongate with row of setae on inner edge; mesofemur with row of seven to nine relatively weak spines along hind edge in basal half (Fig. 40); mesotarsi a little less expanded than protarsi. Metatrochanter tip bluntly pointed (Fig. 41); metafemur elongate, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 a little longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

Male. No external differences between the sexes. Median lobe of aedeagus a little variable in width along shaft, tip bluntly pointed; paramere broad, apical segment relatively short, with long, narrow, apical portion close to rest of segment (Figs 37–39).

Etymology

Named after the type locality.

Remarks

A relatively large species recognised by the lack of a sutural line between the first and second ventrites, the similarity of the basal two antennal segments and a relatively large oval eye remnant.

Tjirtudessus wilunaensis sp. nov.

Types

Holotype: m: 'BES 6433, Wiluna Gold, Lake Violet Borefield bore XPIOB, 26°40'30"S 120°13'55"E, 9/5/200, col. W.F. Humphreys, C.H.S. Watts & S. Cooper'. WAM 32921. Slide mounted.

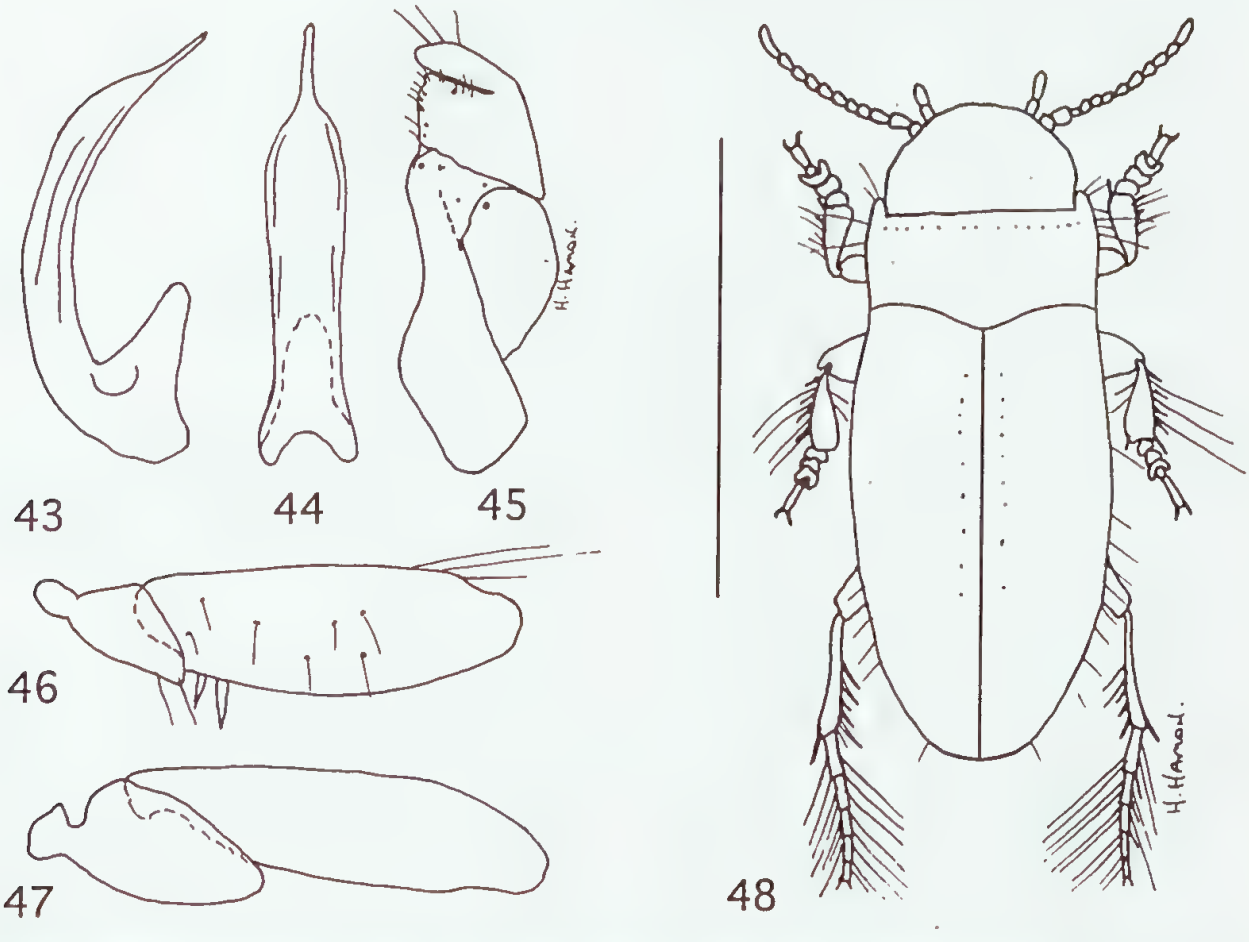
Paratype: 1, 'BES 5640, Millbillillie Pastoral station. Bore nr. Bubble Well, 26°33'39"S 120°02'27"E, 8/5/2001 coll. W.F. Humphreys, C.H.S. Watts & S. Cooper', SAMA. There is some doubt regarding this locality: the field notes suggest that it could have come from the same locality as the holotype.

Description (number examined, 2) Figs 43–48

Habitus. Length 1.4 mm; relatively flat, very weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing reduced, about three-quarters length of elytron.

Head. Slightly narrower than elytra; smooth, reticulation weak, punctures sparse, very small; subparallel in posterior half, bulging just behind eye remnant; eye remnant reduced to a small triangular structure. Antenna stout, segment 1 large, cylindrical, segment 2 larger, barrel-shaped, segment 3 a bit shorter, about one-half as wide as long narrowing towards base, segment 4 bit narrower and one-half the length of segment 3, segments 5 to 10 subequal, segment 11 twice length of segment 10, thinner. Maxillary palpus stout, segment 4 a little shorter than segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. About as wide as elytra; anteriolateral angles projecting strongly forward; base very slightly narrowed, posterolateral angles obtuse; smooth, with sparse, very weak punctures and a row of stronger punctures along front



FIGURES 43–48. *Tjirtudessus wilunaensis*: **43**, lateral view of central lobe of aedeagus; **44**, ditto dorsal view; **45**, paramere; **46**, mesotrochanter and mesofemur; **47**, metatrochanter and metafemur; **48** dorsal view. Scale bar represents 1 mm (habitus only).

margin; basal plicae if present not visible on the two mounted specimens; with row of long setae laterally, denser towards front.

Elytra. Possibly fused, lacking inner ridges; elongate, widest in front of middle, smooth, covered with very small punctures, sparse row of large punctures near suture; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides. Epipleuron undifferentiated, that portion of elytra visible ventrally relatively broad in anterior fifth, then rapidly narrowing to be virtually absent along rest of elytron.

Ventral surface. Prosternal process strongly narrowed between coxae, almost reaching mesothorax, apical half relatively broad, triangular with blunt tip, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae slightly separate. Metasternum sharply triangular in front in midline; wings very narrow; slightly pointed in midline behind. Metacoxal plates large, metacoxal lines obsolete; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia triangular, widest at apex where it is about three times its basal width; protarsi expanded, segments 1 to 3 broad, segment 2 about one-half length of segment 1, segment 3 as long as segment 1, very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about twice length of segment 3, segments 1 to 3 with a covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few setae on inner edge; mesofemur elongate/oval with two strong spines near base on hind edge (Fig. 46); mesotarsi much less expanded than protarsi. Metatrochanter tip elongate/oval (Fig. 47); metafemur relatively broad, lacking spines; metatibia moderately curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 a little longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

Male. No external differences between the sexes. Median lobe of aedeagus relatively broad, sharply narrowing to apex, tip bluntly pointed; paramere broad, apical segment moderately long, with long, club-shaped apical lobe tending to overlap rest of segment, slightly wider than adjacent part of apical segment (Figs 43–45).

Etymology

Named after the type locality.

Remarks

A very small almost parallel-sided species with almost no pronotal constriction and a short fourth segment of the antenna which is only a little more than one-half the length of the third. So far unique among the Australian dytiscid stygofauna in having the tip of the pronotal process meeting, or almost meeting, the forward extension of the mesosternum, slightly separating the mesocoxae.

The eye remnant is little more than a short bifurcation of the more usual suture line on the ventral surface. In the key it has been scored as present. The species will run to *T. pinnaclesensis* if it is considered absent, from which the separate mesocoxae and lack of pronotal constriction will separate it.

Tjirtudessus yuinmeryensis sp. nov

Types

Holotype: m: 'BES 6654, Yuinmery Station, New Well, 28°32'62"S 119°05'28"E, 15/5/2001, col. W.F. Humphreys, C.H.S. Watts & S. Cooper', WAM 32922. Slide mounted.

Paratypes: 53; 7, as for holotype, WAM 32923–32929; 46, as for holotype except 'BES 6653', 20 WAM 32930–32949, 26 SAMA; 1, 'BES 8063, Yuinmery Station, Nine Mile Well, 28°32'35"S 119°08'00"E, 15/5/2001, col. W.F. Humphreys, C.H.S. Watts & S. Cooper', WAM 32950.

Description (number examined, 54) Figs 49–54

Habitus. Length 1.6–2.0 mm; relatively flat, narrow. Moderately constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about one-half length of elytron.

Head. Narrower than elytra; smooth, reticulation very weak, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to single suture tending to widen or thicken ventrally. Antenna relatively stout, segment 1 cylindrical, segment 2 barrel-shaped, segment 3 a little shorter and much narrower and narrowing towards base, segment 4 shorter than segment 3, segments 5 to 10 subequal, segment 11 about twice length of segment 10. Maxillary palpus elongate, segment 4 about length of segments 1 to

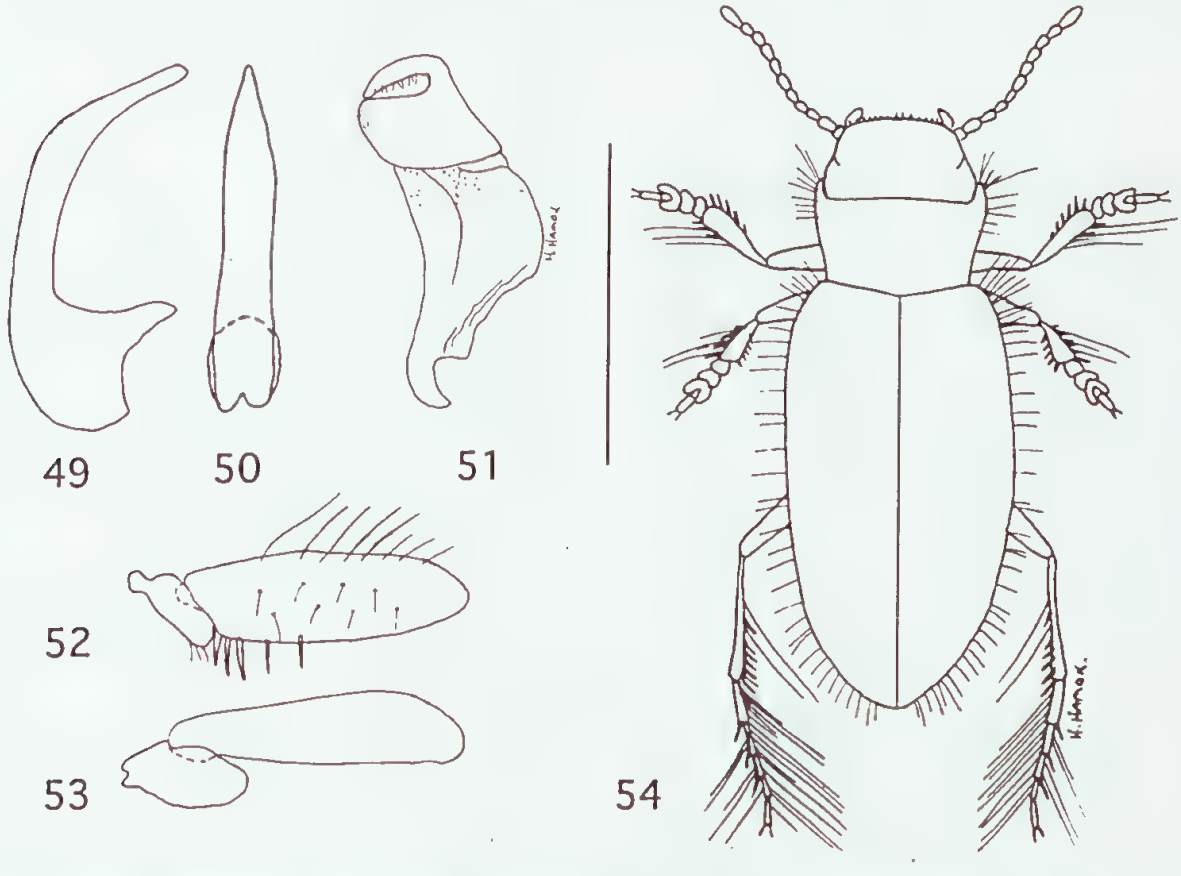
3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. Almost as wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute; smooth, with sparse, very weak punctures; basal plicae moderately marked, straight, reaching to about halfway along pronotum, slightly excavated inwards; with row of long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with very small punctures; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with a few setiferous micropunctures near base and on epipleuron near base. Epipleuron not differentiated, that part of elytron visible ventrally broad in anterior fifth, then rapidly narrowing to be virtually absent along rest of elytron.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half moderately broad, almost parallel-sided, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply triangular in front in midline; wings very narrow; rounded in midline behind. Metacoxal plates large, metacoxal lines moderately widely spaced, reaching to about halfway to metasternum, diverging slightly towards front; a few small setae-bearing punctures towards midline; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines distinct towards midline, becoming indistinct laterally, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia relatively broad, inner edge straight, outer edge bowed, widest near apex where it is about four times its basal width; protarsi weakly expanded, segment 1 subrectangular, segment 2 as wide and about one-half length of segment 1, segment 3 as long as segment 1 but a little narrower and very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate/oval with a few setae near apex; mesofemur with row of five to six relatively strong spines along hind edge in basal half (Fig. 52); mesotarsi similar to protarsi.



FIGURES 49–54. *Tjirtudessus yuinmeryensis*: **49**, lateral view of central lobe of aedeagus; **50**, ditto dorsal view; **51**, paramere; **52**, mesotrochanter and mesofemur; **53**, metatrochanter and metafemur; **54** dorsal view. Scale bar represents 1 mm (habitus only).

Metatrochanter tip rounded (Fig. 53); metafemur elongate, widest beyond middle, lacking spines; metatibia thin, strongly curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

Male. Little external difference between the sexes. Median lobe of aedeagus relatively narrow and narrowing to blunt point; paramere broad, apical segment with long, narrow, apical lobe well separated from rest of segment except near tip (Figs 49–51).

Etymology

Named after the station property on which the species was collected.

Remarks

A relatively small, pale, narrowly elongate species with five to six relatively strong mesofemural spines. Closely resembles *T. masonensis,* from which it can only be separated by a slightly shorter apical lobe to the paramere and by DNA sequencing.

Bidessodes Regimbart

Bidessodes gutteridgei sp. nov.

Types

Holotype: m.: 'BES 8651, Three Rivers Station, Limestone Well, 25°16'59"S 119°10'33"E, 26/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32952. Slide mounted.

Paratypes: 18; 2, 'BES 8605, Three Rivers Station, bore MB4 Plutonic Borefield, 25°16'43"S 119°11'00"E, 26/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', 1 WAM 32953, 1 SAMA; 2, 'BES 8613, Three Rivers Station, Site 312, Old production bore, Plutonic Borefield, 25.26745°S 119.16398°E, 26/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32954–32955; 1 (partial), 'BES 8620, Three Rivers Station, bore MB5, Plutonic Borefield, 25.26730°S 119.16417°E, 26/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32956; 5, 'BES 8625, Three Rivers Station, Limestone Well, 25.28313°S 119.175773°E, 26/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', 2 WAM 32957–32958, 3 SAMA; 3, Ditto except, 'BES 8651', SAMA; 2 (1 partial), 'BES 8633; Three Rivers Station, bore MB3, Plutonic Borefield, 25.26943°S 119.17202°E, 26/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32959–32960; 3, 'BES 8656/7, Three Rivers Station, bore MB2, Plutonic Borefield, 25.27360°S 119.17200°E, 26/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', 2 WAM 32961–32962, 1 SAMA.

Description (number examined, 19) Figs 55–60

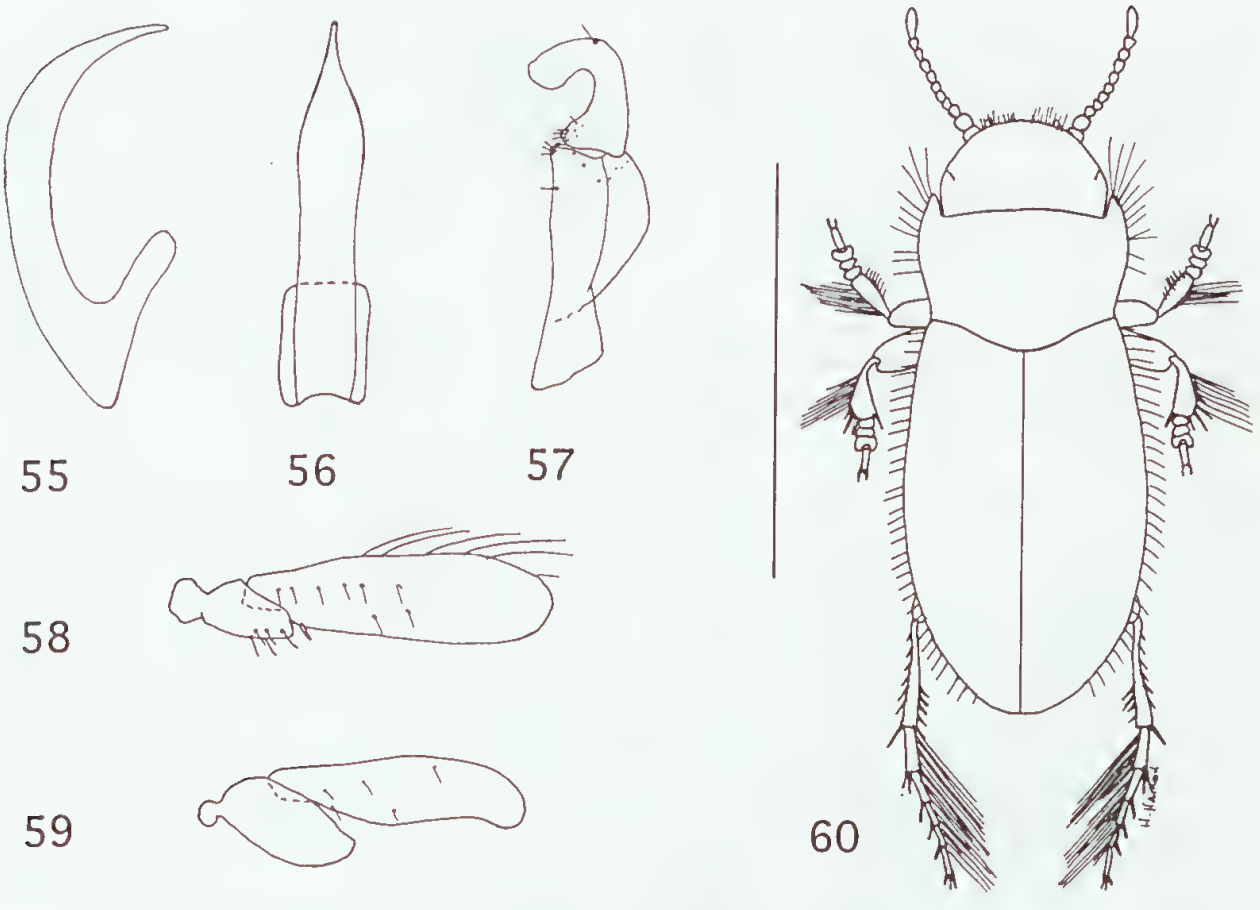
Habitus. Length 1.3–1.5 mm; broadly oval, relatively flat, weakly constricted at base of pronotum; uniformly light testaceous; hindwing vestigial, about one-quarter length of elytron.

Head. A little narrower than elytra; smooth, reticulation strong, punctures sparse, very small; subparallel in posterior half, widest just behind eye remnant; eye remnant reduced to single suture. Antenna relatively stout, segment 1 cylindrical, segment 2 oval, segment 3 much smaller and narrower, segments 4 to 10 equal in length becoming progressively wider, segment 11 about twice length of segment 10. Maxillary palpus stout, segment 4 a little shorter than segments 1 to 3 combined, oblique row of long setae on outer side, tip truncated.

Pronotum. Almost as wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles obtuse; smooth, with sparse, very weak punctures and a row of stronger punctures along front margin; strongly reticulate; basal plicae absent; with row of long setae laterally, denser towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest in middle, smooth, sparsely covered with small punctures each with a short seta; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with a few setiferous micropunctures towards apex and sides. Epipleuron undifferentiated; portion of elytron visible ventrally thin except for extreme shoulder.

Ventral surface. Prosternal process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half almost parallel-sided, tip with small point, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply triangular in front in midline; wings very narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines relatively well marked, quite widely spaced, reaching nearly to metasternum, weakly diverging towards front; a few small setae-bearing punctures



FIGURES 55–60. *Bidessodes gutteridgei*: **55**, lateral view of central lobe of aedeagus; **56**, ditto dorsal view; **57**, paramere; **58**, mesotrochanter and mesofemur; **59**, metatrochanter and metafemur; **60** dorsal view. Scale bar represents 1 mm (habitus only).

towards midline; strongly reticulate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct towards midline, becoming indistinct laterally, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, ventrites 3 and 4 with a long central seta or bunch of long setae; strongly reticulate.

Legs. Protibia broad, inner edge straight, outer edge bowed, widest near apex where it is about four times its basal width; protarsi quite strongly expanded, segment 1 broad, narrowing at base, segment 2 a little wider and a little shorter than segment 1, segment 3 as long as first and a bit wider, very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about twice length of segment 3, segments 1 to 3 with quite dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with row of three to four spines on inner edge; mesofemur with row of six short spines along hind edge in basal half (Fig. 58); mesotibia broad, slightly angular; mesotarsi narrower than protarsi. Metatrochanter tip rounded, well separated from femur (Fig. 59); metafemur stout, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 a little longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

Male. No external differences between the sexes. Median lobe of aedeagus variable in width along shaft, tip bluntly pointed; paramere broad, apical segment hook-shaped (Figs 55–57).

Etymology

Named after Rob Gutteridge, who has very ably illustrated many of these beetles.

Remarks

A small species best recognised by the stout antenna, slightly angular mesotibia and large metatrochanter with its tip well separated from the metafemur. Its placement in *Bidessodes* is based primarily on evidence from DNA sequence data which suggest a relationship with *B. limestoneensis* and, more distantly, with *B. bilita*

Watts and *B. mjobergi* (Zimmermann.) (See also under *B. limestoneensis*.). There are no morphological characters that would negate its placement in *Bidessodes* as currently defined.

Bidessodes limestoneensis sp. nov.

Types

Holotype: m: 'BES 8625, Three Rivers Station, Limestone Well, 25°16'59"S 119°10'33"E, 26/8/2001, W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32951. In spirit.

Description (number examined, 1) Figs 61–66

Habitus. Length 4.2 mm; relatively flat, strongly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about one-half length of elytron.

Head. About as wide as elytra; smooth, moderately reticulate with small meshes, punctures sparse, very small; subparallel in posterior half, widest in middle behind eye remnant; eye remnant reduced to two well-separated short sutures at side of head. Antenna very thin, segments subequal, apical segment a bit longer than penultimate (Fig. 66). Maxillary palpus thin, elongate, apical segment about same length as segments 1 to 3 combined.

Pronotum. As wide as elytra; anteriolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles obtuse; smooth, moderately reticulate, meshes small; punctures sparse, weak; basal plicae weak, straight, reaching to about one-quarter way along pronotum; with row of long setae laterally, denser towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, sparsely covered with small shallow punctures, row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides. Epipleuron weakly differentiated, that portion of elytron visible ventrally broad in anterior fifth, then rapidly narrowing to be virtually absent along rest of elytron.

Ventral surface. Prosternal process moderately broad, strongly narrowed between coxae, not reaching mesothorax, apical half almost parallel-sided, tip rounded, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly triangular in front in midline; wings short, very narrow; broadly rounded in midline behind; reaching a little beyond midway to metacoxae. Metacoxal plates large, metacoxal lines weakly defined, relatively close, moderately widely spaced, reaching nearly to metasternum, evenly diverging; a few small setae-bearing punctures towards midline; finely reticulate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct towards midline, becoming indistinct laterally, ventrites 3 to 5 mobile, sparsely covered with small seta-bearing punctures, weakly reticulate, ventrites 3 and 4 with a long central seta or bunch of long setae.

Legs. Protibia very narrow, slightly bowed, widest past middle where it is about three times its basal width; protarsi expanded, segment 1 round, segment 2 a little broader and a little shorter, segment 3 about twice as long and as broad as segment 1 and very deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with very dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with row of setae on inner edge; mesofemur with two comb-like rows of spines along hind edge (Fig. 64); mesotibia narrow, more strongly bowed than protibia; mesotarsi narrower than protarsi. Metatrochanter tip rounded (Fig. 65); metafemur elongate, lacking spines; metatibia thin, curved, widening towards apex; metatarsi elongate, segment 1 longest, segment 5 a little longer than segment 4, segments 1 and 2 in combination about as long as others; claws weak.

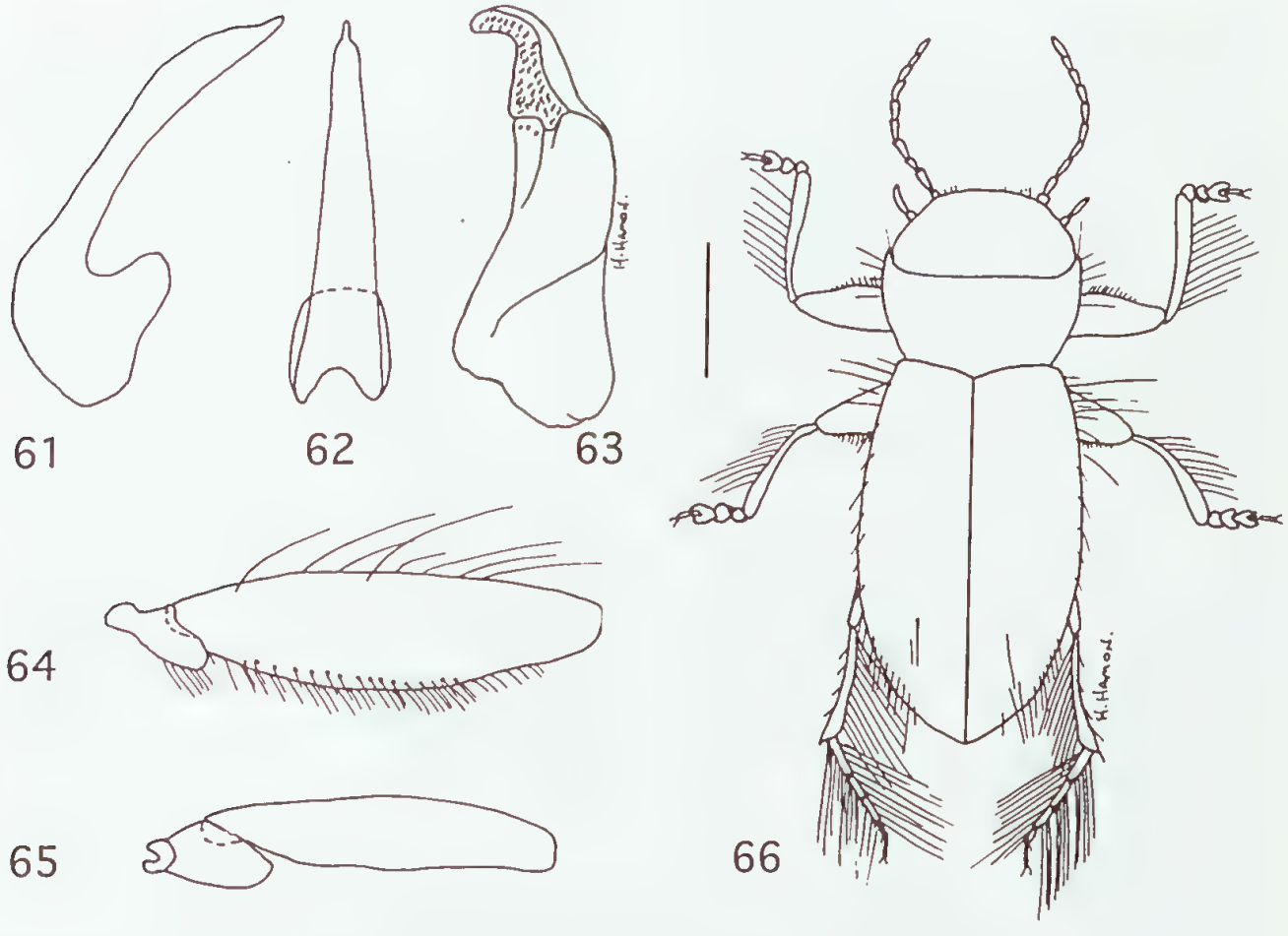
Male. Female not known. Median lobe of aedeagus progressively narrowing to near apex where it rapidly narrows to blunt tip; paramere narrow, apical portion without well separated apical lobe, apical segment with inner half with different surface texture to outer (Figs 61–63).

Etymology

Named after the type locality.

Remarks

A relatively large species with numerous characters setting it apart from other Australian stygobitic Bidessini. Most noticeably the long thin antenna, bowed mesotibia and unusually thin legs. The species will key to *Bidessodes* in Bistrom (1988) and the male genitalia resemble *B flavosignatus* (Zimmermann). DNA sequence data (Cooper et al 2002) somewhat distantly groups it with the previous species, *B. gutteridgei* sp. nov., and with *B. bilita* and *B. mjobergi*. Its large size



FIGURES 61–66. *Bidessodes limestoneensis*: **61**, lateral view of central lobe of aedeagus; **62**, ditto dorsal view; **63**, paramere; **64**, mesotrochanter and mesofemur; **65**, metatrochanter and metafemur; **66** dorsal view. Scale bar represents 1 mm (habitus only).

and thin prolegs readily separate it from *B. gutteridgei*. Additional studies incorporating more specimens of Australian *Bidessodes* (which DNA sequence data strongly suggest are not closely related to the South American *Bidessodes*) and additional specimens are needed to confirm the placement of *B. limestoneensis* with the Australian *Bidessodes*.

Nirripirti Watts & Humphreys

Nirripirti darlotensis sp. nov.

Types

Holotype: m: 'BES 6635, Melrose Station (Lake Darlot), mineral exploration bore near Halfpenny Well, 27°41'48"S 121°20'22"E, 13/5/2001, coll. W.F. Humphreys, C.H.S. Watts & S. Cooper', WAM 32963. Slide mounted.

Paratypes: 11, 7 (2 partial) as for holotype, 5 (2 partial) WAM 32964–32968, 2 SAMA; 2, as for holotype except 'BES 6636', WAM 32969–32970; 2, as for holotype except 'BES 6639', SAMA.

Description (number examined, 12) Figs 67–72

Habitus. Length 3.5–4.1 mm; elongate, relatively flat, slightly pug-nosed, moderately constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing reduced to one-third length of elytron.

Head. Large, almost as wide as elytra; smooth, very weakly reticulate, scattered small punctures and dense band of setiferous punctures across rear; sides subparallel in posterior half; eye remnant reduced to a small suture in middle near edge. Antenna thin, segments 1 and 2 cylindrical, segments 3 to 10 subequal with segment 7 largest, segment 11 a bit longer than segment 10. Maxillary palpus thin, elongate, segment 4 a little longer than segment 3.

Pronotum. About as wide as elytra; anteriolateral angles thin, projecting strongly forward; moderately narrowed before base, sides slightly sinuate; posterolateral angles obtuse;

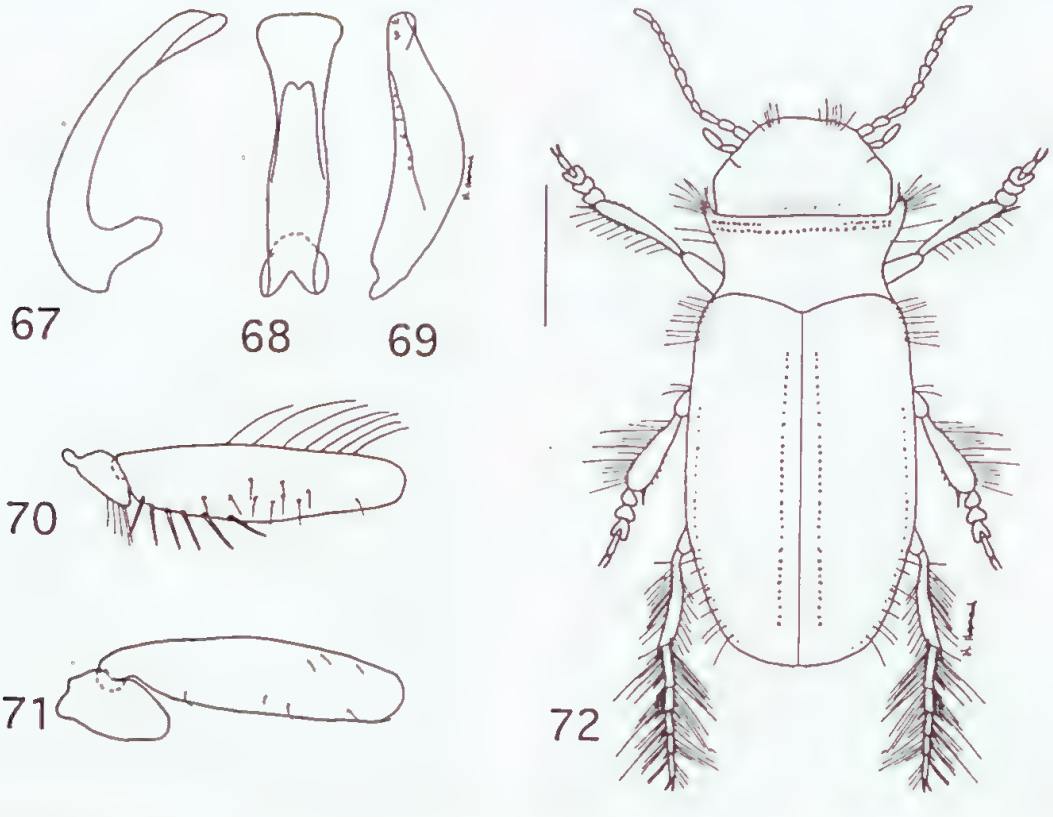
virtually impunctate except for band of strong punctures along front margin; long lateral setae restricted to apical third.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate/oval, widest behind middle, smooth, a few scattered very small punctures, a row of punctures adjacent to suture; a few additional larger punctures with long setae, more frequent towards sides. Setiferous micropunctures over most of underside, denser at base, apex and along suture line. Epipleuron not differentiated from rest of elytron, that part of elytron visible ventrally relatively broad for almost the whole length of elytron.

Ventral surface. Prosternal process very narrow between coxae, not reaching mesothorax, apical half narrowly spatulate, point rounded, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum triangularly pointed in front in midline; wings very narrow, short; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct in inner half indistinct towards sides, ventrites 3 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Protibia narrow, widest a little past middle where it is about four times its very narrow basal width; protarsi moderately expanded, segment 1 transversely oval, segment 2 about size of segment 1, segment 3 about twice length of segment 2, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of seven to eight relatively long but weak spines along hind edge in basal half; mesotarsi less expanded than protarsi. Metatrochanter elongate/oval, tip rounded; metafemur thin, lacking spines; metatibia weakly curved, widening slightly towards apex; metatarsi elongate, segment 1 longest, segments 2 to 4 subequal, in combination segments 1 and 2 about same length as others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Antennae of male slightly stouter than female. Median lobe of aedeagus broad, flat, widening at apex; paramere relatively narrow, apex rounded with small flap of tissue (Figs 67–69).



FIGURES 67–72. *Nirripirti darlotensis*: **67**, lateral view of central lobe of aedeagus; **68**, ditto dorsal view; **69**, paramere; **70**, mesotrochanter and mesofemur; **71**, metatrochanter and metafemur; **72** dorsal view. Scale bar represents 1 mm (habitus only).

Etymology

Named after the type locality.

Remarks

A large species with the elytra tending to wrap around the abdomen, and with thin antennae with segment 3 a bit longer than segment 2. The only other species to have a broad band of small setiferous punctures across the back of the head is the much smaller *N. melroseensis* which was collected from the same bore hole.

Nirripirti fortisspina sp. nov.

Types

Holotype: m: 'BES 6645, Pinnacles Station, Site 432, 28°15'27"S 120°07'37"E, 14/5/2001, col. W.F. Humphreys, C.H.S. Watts & S. Cooper', WAM 32971. Slide mounted.

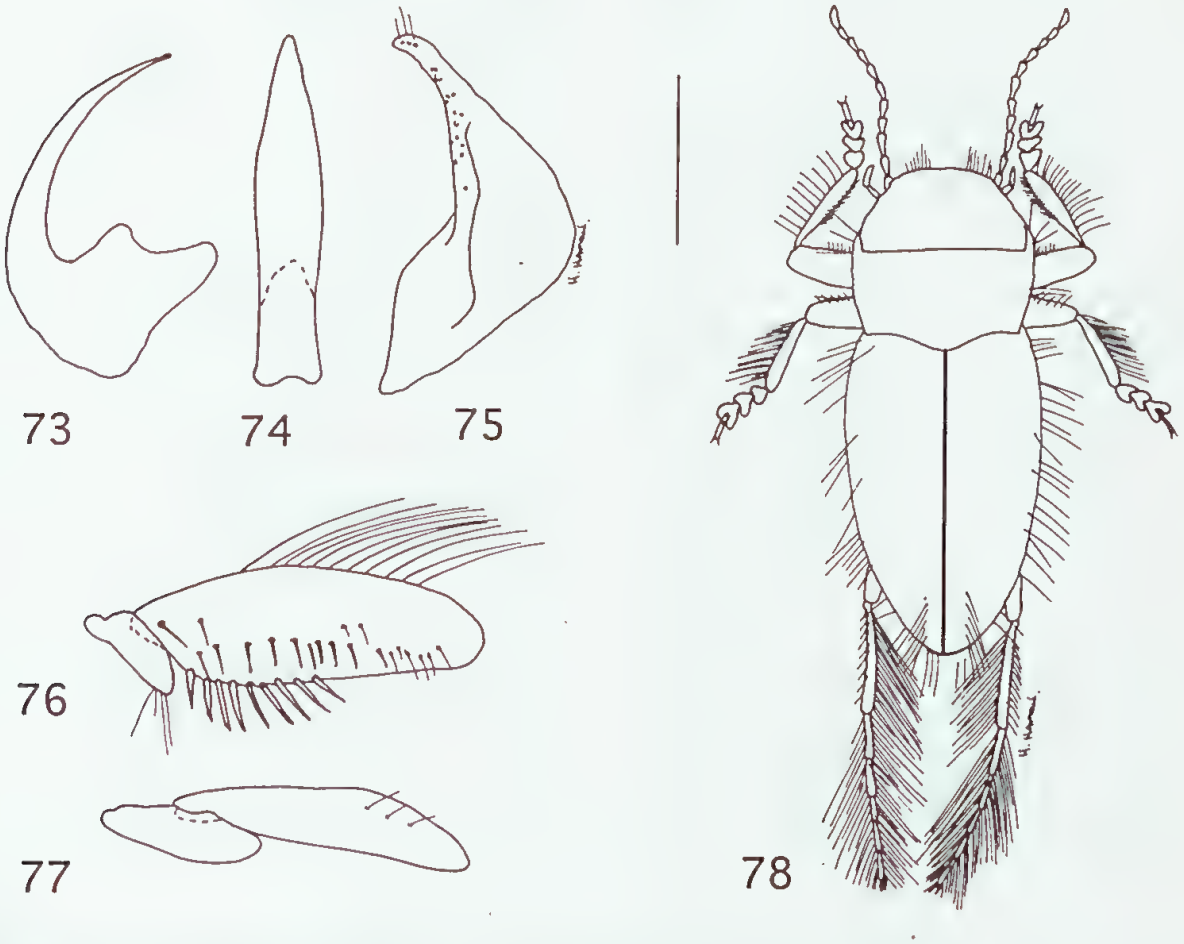
Paratypes. 15; 13, as for holotype, 7 WAM 32972–32978, 6 SAMA; 2, as for holotype except 'BES 6646', SAMA.

Description (number examined, 16) Figs 73–78

Habitus. Length 2.5–3.0 mm. elongate, relatively flat, weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, reduced to small flap.

Head. Large, nearly as wide as elytra; smooth, weakly reticulate with small even meshes, a few small scattered punctures; sides subparallel in posterior half; eye remnant reduced to a short suture near edge. Antenna thin, segments 1 and 2 almost cylindrical, segments 3 to 10 approximately same length, widening slightly towards their apexes, segments 3 and 4 narrowest, segment 11 a bit longer and narrower than segment 10. Maxillary palpus elongate, thin, segment 4 a little longer than segment 3.

Pronotum. About as wide as elytra; anteriolateral angles projecting strongly forward; wider anteriorly, evenly narrowing towards rear, posterolateral angles obtuse; very weakly reticulate, virtually impunctate except towards front margin, numerous long setae at side towards front.



FIGURES 73–78. *Nirripirti fortisspina*: **73**, lateral view of central lobe of aedeagus; **74**, ditto dorsal view; **75**, paramere; **76**, mesotrochanter and mesofemur; **77**, metatrochanter and metafemur; **78** dorsal view. Scale bar represents 1 mm (habitus only).

Elytra. Not fused but tightly locked, lacking inner ridges; elongate, widest a bit anterior of middle, smooth, covered with fine reticulation; moderate number of relatively large punctures laterally; underside with dense setiferous micropunctures at apex and along suture line. Epipleuron not differentiated from rest of elytron, that part of elytron visible ventrally broad in anterior quarter, then gradually narrowing, absent near apex of elytron.

Ventral surface. Prosternum very narrow, not much wider than procoxae; anterior half of prosternal process almost perpendicular to body, strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum only weakly extended forward in midline; wings very short, narrow; main portion almost parallel-sided; rounded in midline behind. Metacoxal plates large, metacoxal lines absent; weakly reticulate, impunctate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct, ventrites 3 to 5 mobile, weakly reticulate, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Profemur with small peg-like seta on hind edge adjacent to trochanter; protibia narrow, widest past middle where it is about twice its basal width; protarsi quite strongly expanded, segment 1 broadly elongate not symmetric, basal half expanded backwards, apical half more expanded forwards, segment 2 about one-half length of segment 1, outer lobe more expanded; segment 3 as long as segment 1, deeply bifid, lobes slightly asymmetric; segment 4 very small and hidden within lobes of segment 3; segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of eight to nine very strong spines closely spaced along hind edge in basal half; mesotarsi symmetric, less expanded than protarsi. Metatrochanter narrowly elongate, apical half well separated from femur; metafemur thin, elongate, lacking spines; metatibia thin, weakly curved, approximately the same width throughout; metatarsi thin, elongate, segment 1 and others subequal in length, in combination segments 1 and 2 much shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Little external difference from female. Median lobe of aedeagus narrowing rapidly in apical quarter; paramere broadest in middle, apical quarter thin, apex with a bunch of short stout setae (Figs. 73–75).

Etymology

Latin. 'Forte spina' – strong spines.

Remarks

A relatively large distinctive species easily recognised by the row of strong spines on the mesofemur and the peculiarly asymmetric protarsi, as well as the thin elongate metatrochanters and thin elongate antenna. The prosternum is short with little area in front of the mesocoxae, resulting in a very perpendicular anterior portion to the prosternal process.

Nirripirti hamoni sp. nov.

Types

Holotype: m: 'BES 8662, Milgun Station, Earrie Well, 25°07'22"S 118°05'44"E, 28/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32979. Slide mounted.

Paratypes: 3; 2, as for holotype, SAMA; 1, as for holotype except 'BES 8661, 27/8/2001', WAM 32980.

Description (number examined, 4) Figs 79–84

Habitus. Length 1.7 mm.; relatively broad, flat, strongly constricted at base of pronotum; elytra slightly flared at shoulders; uniformly light testaceous; hindwing vestigial, reduced to tiny flap.

Head. Relatively small, less than width of elytra; smooth, moderately strong reticulation with small even meshes, virtually impunctate except a few near antennae bases; subparallel in posterior half; eye remnant reduced to a dark suture in middle near edge. Apical half of antenna relatively thick, segment 1 cylindrical, segment 2 oval, segments 3 to 4 much thinner than rest, segments 6 to 7 subequal, broader than segment 5, apical segment a bit longer and narrower than penultimate. Maxillary palpus elongate, segment 4 a little longer than segment 3.

Pronotum. A little narrower than elytra; anteriolateral angles projecting strongly forward to sharp point, sides strongly curved outwards; base strongly narrowed, posterolateral angles acute; strongly reticulate, virtually impunctate except towards front margin and laterally. Numerous long setae at sides towards front.

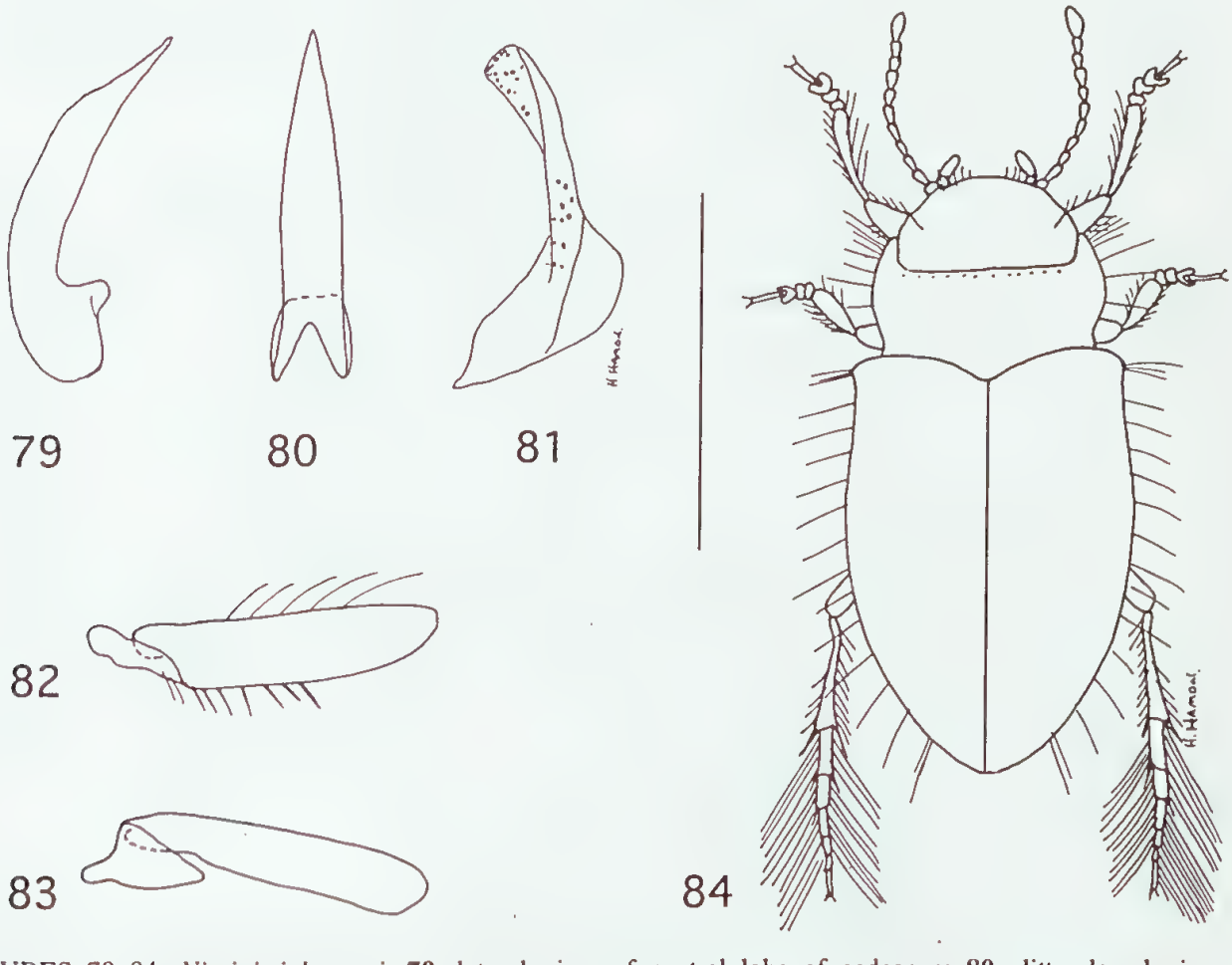
Elytra. Not fused but strongly locked, lacking inner ridges; elongate, widest in front of middle,

slightly constricted behind shoulders, smooth, covered with strong reticulation; moderately and evenly covered with small punctures; underside of elytron with a few additional larger punctures with long setae, more frequent towards sides; with numerous setiferous micropunctures densest towards apex and along suture line. Epipleuron not differentiated from rest of elytron, broad in anterior fifth, then rapidly narrowing to middle, virtually absent along rest of elytron.

Ventral surface. Prosternal process broad, strongly narrowed between coxae, not reaching mesothorax, apical half oval, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply pointed in front in midline; wings short, very narrow; narrowly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate, strongly reticulate with large meshes; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct except close to sides, ventrites 3 to 5 mobile, virtually impunctate except for a few long central setae or bunch of long setae.

Legs. Profemur noticeably grooved in apical half to accept protibia; protibia narrow, widest past middle where it is about three times its basal width; protarsi expanded, segment 1 broad, segment 2 about one-half length of segment 1, segment 3 relatively narrow, as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of four to five strong spines along hind edge in basal half; mesotarsi a little less expanded than protarsi. Metatrochanter relatively small, tip pointed; metafemur thin, lacking spines; metatibia relatively stout, very weakly curved, approximately the same width throughout; metatarsi relatively stout, segment 1 longest, segment 5 a little longer than segment 4, segments 1 and 2 in combination much shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Male appendages not known. Median



FIGURES 79–84. *Nirripirti hamoni*: **79**, lateral view of central lobe of aedeagus; **80**, ditto dorsal view; **81**, paramere; **82**, mesotrochanter and mesofemur; **83**, metatrochanter and metafemur; **84** dorsal view. Scale bar represents 1 mm (habitus only).

lobe of aedeagus narrowing rapidly in apical quarter; paramere broad at base, apical half thin, tip with a bunch of long setae (Figs. 79–81).

Etymology

Named after Harold Hamon, the illustrator of many of these beetles.

Remarks

A relatively small, strongly chitinised species easily recognised by its flared shoulders and strongly constricted pronotum and pointed metatrochanters.

Nirripirti killaraensis sp. nov.

Types

Holotype: m: 'BES 5561, Killara Station, Two Mile Bore, 26°21'11"S; 118°59'34"E, 5/5/2001, col. W.F. Humphreys, C.H.S. Watts & S. Cooper', WAM 32981. Slide mounted.

Paratypes: 19; 1, as for holotype, SAMA; 1, 'BES 5597, Killara Station, uncased mineral exploration bore, Site 130, 26.34194°S; 118.96071°E, 6/5/2001, col. W.F. Humphreys, C.H.S. Watts & S. Cooper', SAMA; 8, 'BES 8125, Killara Station, Site 130, 26°20'31"S, 118°57'39"E, 21/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32928–32989; 9, ditto, except 'BES 8128', SAMA.

Description (number examined, 20) Figs 85–90

Habitus. Length 1.5–1.9 mm; boat-shaped, relatively flat, weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, reduced to tiny flap.

Head, Narrower than elytra; smooth, moderately strong reticulation with small even meshes, virtually impunctate except a few near antennae bases arranged in lines; sides slightly curved; eye remnant reduced to a short suture in middle near edge. Antenna relatively thick, segment 1 narrow, cylindrical, segment 2 much larger, rounded, narrower at base, segments 3 and 4 narrow, segments 6 to 8 a bit wider that others, segment 11 is 1.5 times longer than penultimate. Maxillary palpus elongate, apical segment about as long as other segments combined.

Pronotum. Narrower than elytra; anteriolateral angles projecting strongly forward; sides weakly sinuate, posterolateral angles obtuse; quite strongly reticulate, a few small scattered punctures. Long setae at sides

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest behind middle, smooth, covered with fine reticulation; a few scattered small punctures, a few additional larger punctures with long setae, more frequent towards sides, underside with setiferous micropunctures at base, apex and along suture line. Epipleuron not differentiated; that portion of elytra visible ventrally, broad except near tip.

Ventral surface. Prosternal process strongly narrowed between coxae, tip pointed, nearly reaching mesothorax, apical half parallel with plane of body, anterior section perpendicular to plane of body, prosternum short and not much wider than procoxae. Mesocoxae in contact at midline. Metasternum bluntly pointed in front in midline; wings very narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate, reticulate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct in inner three-quarters and indistinct laterally, ventrites 3 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae, strongly reticulate, meshes small.

Legs. Protibia narrow, widest past middle where it is about twice its basal width; protarsi weakly expanded, segment 1 broadly triangular, segment 2 about one-half length of segment 1, segment 3 as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, a little longer than segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of four to five spines along hind edge in basal half; mesotarsi much narrower than protarsi. Metatrochanter elongate/oval, apex bluntly pointed; metafemur elongate, lacking spines; metatibia almost straight, approximately the same width throughout; metatarsi elongate, segment 1 longest, segments 2 to 4 subequal, segments 1 and 2 in combination about same length as others, segments 2 to 5 without spines other than at apex; claws weak.

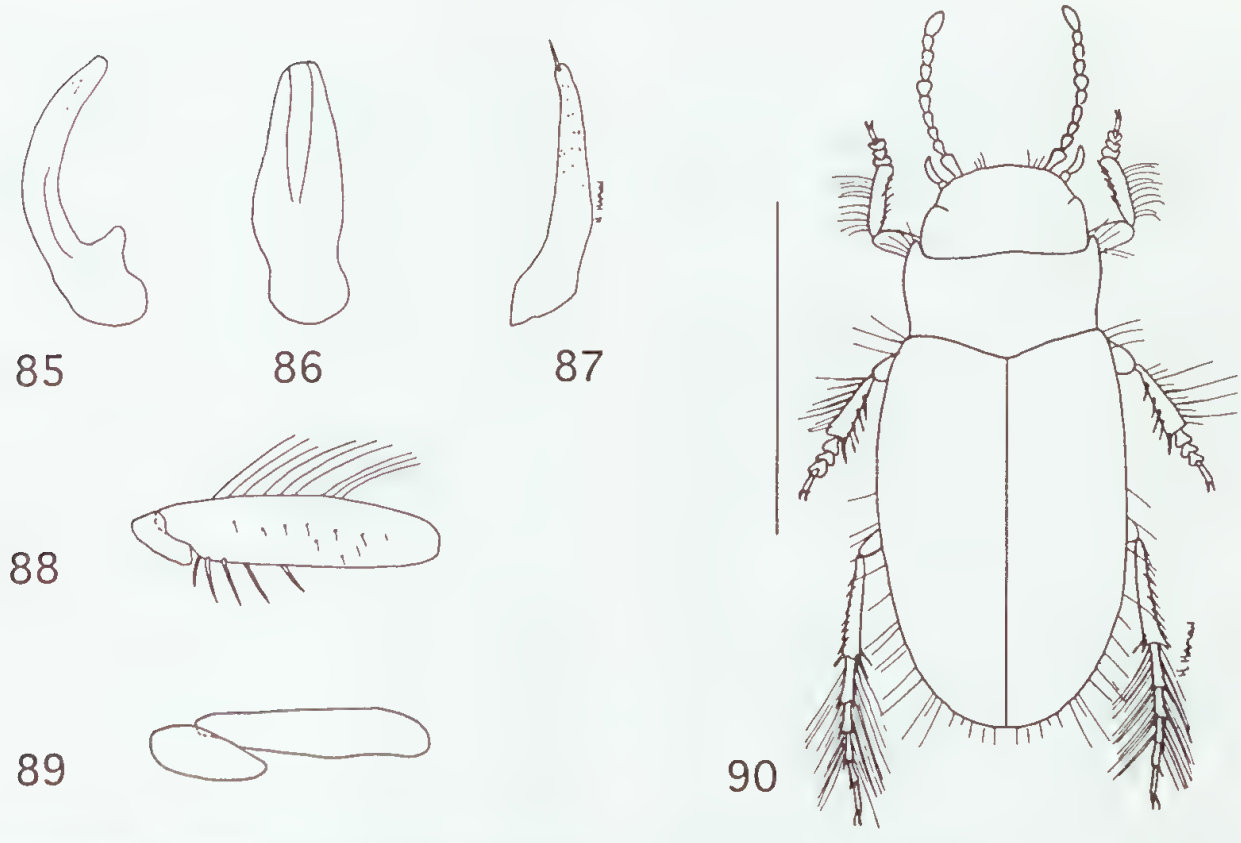
Male. Little difference from female. Median lobe of aedeagus narrowing rapidly in apical quarter; paramere broad at base, apical half thin, tip with a bunch of long setae (Figs. 85–87).

Etymology

Named after the pastoral station on which it was found.

Remarks

A moderately sized, boat-shaped species with



FIGURES 85–90. *Nirripirti killaraensis*: **85**, lateral view of central lobe of aedeagus; **86**, ditto dorsal view; **87**, paramere; **88**, mesotrochanter and mesofemur; **89**, metatrochanter and metafemur; **90** dorsal view. Scale bar represents 1 mm (habitus only).

wrap-around elytra, and a pronotal process with a long point which nearly reaches the extension of the metasternum. A little smaller than the other boat-shaped Western Australian species, *N. skaphites*, and with the apex of the metatrochanters more rounded.

Nirripirti macrocephalus sp. nov.

Types

Holotype: male: 'BES 8089 NT: Napperby Station; bore RN 1561@ Herbert Well; 22°54'32"S 132°43'45"E; 18/6/2001. Col. W.F. Humphreys & R. Read.', NTM, I 001174. Slide mounted.

Paratype: 1, as for holotype, SAMA.

Description (number examined, 2) Figs 91–96

Habitus. Length 1.9–2.0 mm.; oval, relatively flat, strongly constricted at junction of pronotum/elytra; light testaceous, head a little darker; hindwing vestigial, reduced to tiny flap.

Head. Large, short, broad, deflexed downwards, as wide as elytra; smooth, weakly reticulate, virtually impunctate except a few small ones near antennae bases; sides subparallel in posterior half; eye remnant reduced to a short suture in middle. Antenna thin, segments 1 and 2 cylindrical, segments 3 and 4 much thinner, 5 to 10 triangular, broader middle segments slightly larger, segment 11 twice length of segment 10. Maxillary palpus thin, elongate, segment 4 much longer than segment 5, some long setae towards apex of segments.

Pronotum. A little wider than elytra, much broader then long; anteriolateral angles projecting strongly forward, anterior edge sinuate; strongly constricted just before base, posterolateral angles acute; a few scattered very small punctures; numerous long setae at sides particularly towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; broad, widest at shoulders, smooth; weakly reticulate; a few scattered small punctures, some arranged in rows; a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with numerous, evenly spaced, setiferous micropunctures denser towards apex. Epipleuron not differentiated, that part of elytron visible ventrally broad in anterior fifth, rapidly

narrowing to be virtually absent along rest of elytron.

Ventral surface. Prosternum short, no longer than postcoxae, anterior portion of prosternal process rising perpendicularly with both a forward and a backward projection, anterior projection broad, rounded, posterior projection (process) broad, triangular; not reaching mesothorax. Mesocoxae in contact at midline. Metasternum bluntly pointed in front in midline; wings absent; broadly rounded in midline behind. Metacoxal plates large, reaching episternum, metacoxal lines absent; virtually impunctate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct in inner half indistinct laterally, ventrites 3 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Protibia very narrow, widest near apex where it is about twice its basal width; protarsi moderately expanded, segment 1 broadly triangular, segment 2 a little shorter, segment 3 longer than segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with long adhesive setae; claws short and simple. Mesotrochanter elongate/ oval, with a few fine setae at apex; mesofemur with row of four strong spines along hind edge in basal half; mesotibia curved, moderately flanged on inside near apex, mesotarsi simple, not expanded. Metatrochanter oval; metafemur elongate, lacking spines; metatibia stout, curved, moderately widening towards apex; metatarsi elongate, segment 1 longest, segment 4 shortest, in combination segments 1 and 2 a little shorter than others, all segments without spines other than at apex; claws weak.

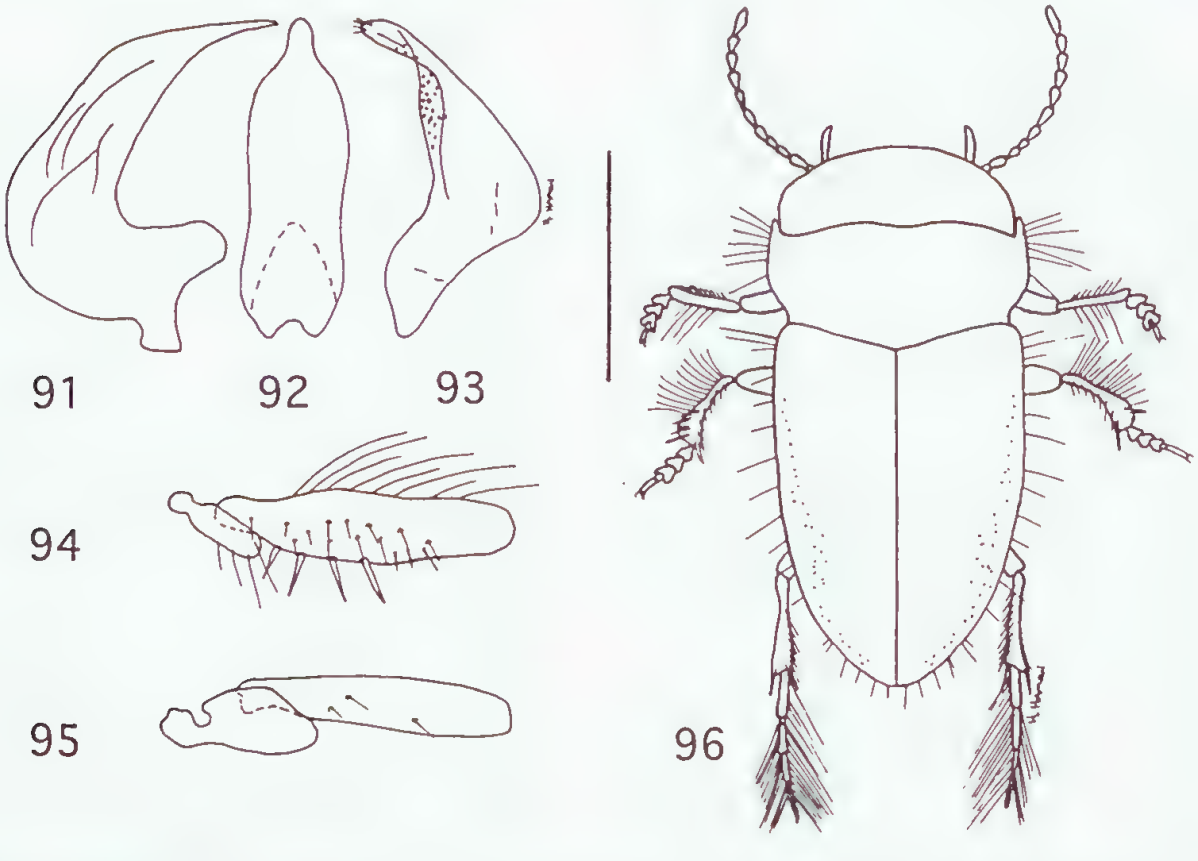
Male. Little difference from female. Median lobe of aedeagus broad, narrowing rapidly in apical quarter to sharp point, apical portion of paramere twisted, apex rounded (Figs 91–93).

Etymology

Latin. 'Macrocephalus'– big head; a reference to its unusually large deflexed head.

Remarks

A distinctive, moderate sized, well chitinised species, easily recognised by its very broad deflexed head as well as its thin legs and strongly constricted pronotum.



FIGURES 91–96. *Nirripirti macrocephalus*: **91**, lateral view of central lobe of aedeagus; **92**, ditto dorsal view; **93**, paramere; **94**, mesotrochanter and mesofemur; **95**, metatrochanter and metafemur; **96** dorsal view. Scale bar represents 1 mm (habitus only).

Nirripirti melroseensis sp. nov.

Types

Holotype: m: 'BES 6635, Melrose Station (Lake Darlot), mineral exploration bore near Halfpenny Well, 27°41'48"S; 121°20'22"E, 13/5/2001, coll. W.F. Humphreys, C.H.S. Watts & S. Cooper', WAM 32990. Slide mounted.

Paratypes: 23; 10, as for holotype, SAMA; 2, as for holotype except 'BES 6639', WAM 32991–32992; 11, as for holotype except 'BES 6636', WAM 33927–33937.

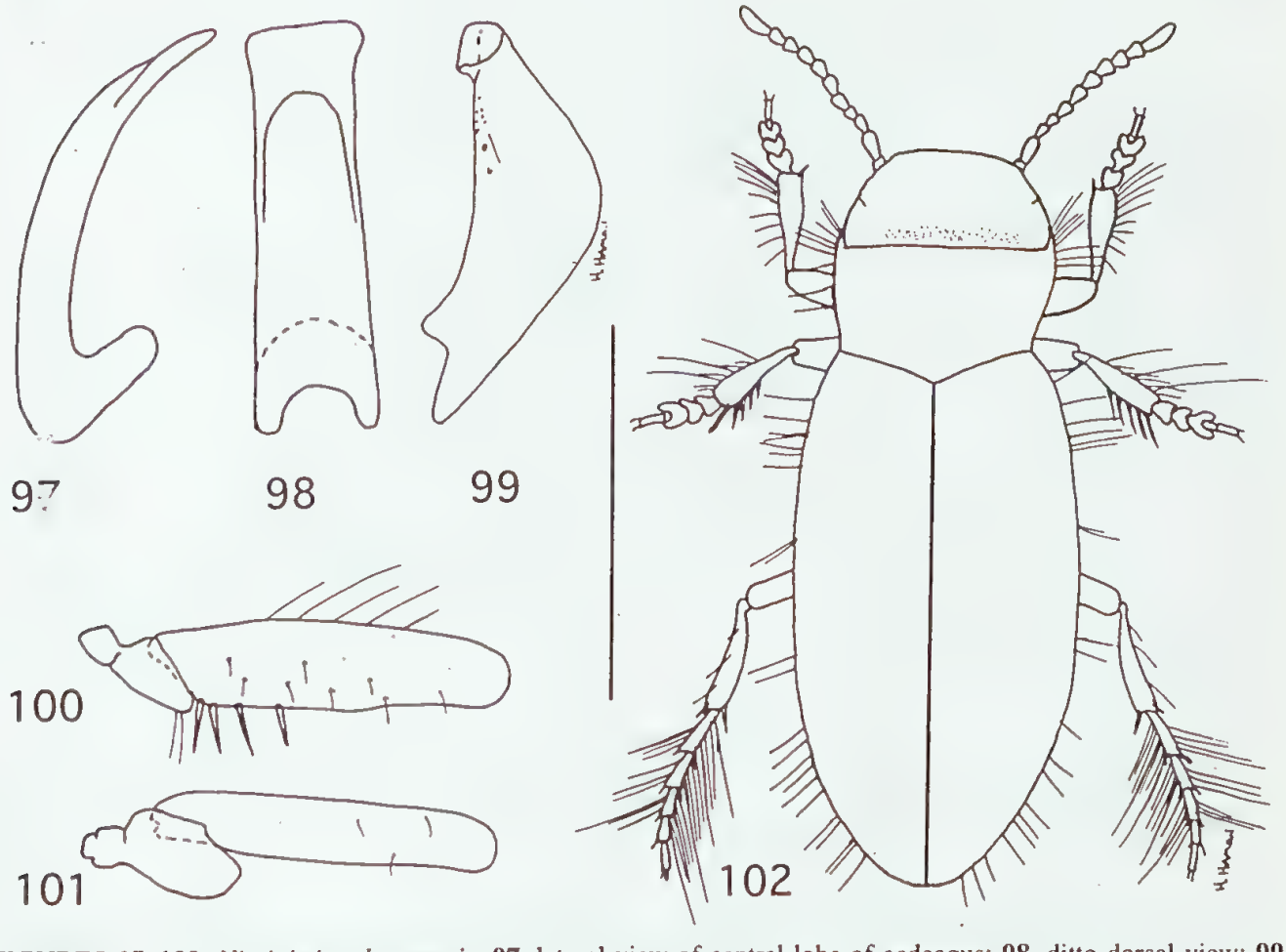
Description (number examined, 24) Figs 97–102

Habitus. Length 1.8–2.0 mm; elongate, relatively flat, weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing reduced to one-third length of elytron.

Head. Much narrower than elytra; smooth, strongly reticulate with small even meshes, moderately dense band of setiferous punctures across rear; sides subparallel in posterior half; eye remnant reduced to a suture in middle at side. Antenna relatively thick, segment 1 robust, cylindrical, segment 2 a little wider and more oval, segments 3 to 10 narrow and shorter, subequal, segment 11 about as wide and a bit longer than segment 10. Maxillary palpus elongate, apical segment about twice as long as segment 10.

Pronotum. Much narrower than elytra, about same width as head; anteriolateral angles projecting strongly forward; sides narrowing slightly posteriorly, posterolateral angles obtuse; strongly reticulate, virtually impunctate except towards front margin and rear corners. Long setae at sides, more extensive towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, almost parallel-sided, smooth, covered with fine reticulation; a few scattered small punctures, several rows of widely spaced small punctures; a sparse row of large shallow punctures adjacent to suture; a few additional larger punctures with long setae, more frequent towards sides; underside of elytron with quite dense setiferous micropunctures at apex and narrowly along suture line. Epipleuron not differentiated, that part of elytron visible ventrally



FIGURES 97–102. *Nirripirti melroseensis*: **97**, lateral view of central lobe of aedeagus; **98**, ditto dorsal view; **99**, paramere; **100**, mesotrochanter and mesofemur; **101**, metatrochanter and metafemur; **102** dorsal view. Scale bar represents 1 mm (habitus only).

moderately broad in anterior quarter, then gradually narrowing to apex.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half relatively narrow, parallel-sided, tip pointed, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly pointed in front in midline; wings short, very narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; strongly reticulate, virtually impunctate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 possibly fused, sutural lines distinct, ventrites 3 to 5 mobile, moderately reticulate, virtually impunctate except for a few long central setae or bunch of long setae.

Legs. Protibia elongate, relatively broad, widest near apex where it is about three times its basal width; protarsi weakly expanded, segment 1 cylindrical, segment 2 about one-half length of segment 1, segment 3 as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about one-half length of segment 3, segments 1 to 3 with covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of four to five strong spines along hind edge in basal half; mesotarsi a little less expanded than protarsi. Metatrochanter elongate/oval, apex somewhat truncated; metafemur thin, lacking spines; metatibia moderately curved, widening somewhat towards apex; metatarsi elongate, segment 1 longest, segment 4 shortest, in combination segments 1 and 2 slightly shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Little external difference between the sexes. Median lobe of aedeagus broad, widening slightly at apex; paramere broad, narrowing towards apex, apex bent over (Figs 97–99).

Etymology

Named after the pastoral station on which it was found.

Remarks

A moderate sized, elongate species, with head and pronotum about the same width and much narrower than elytra, rather squat metatrochanters and thin metafemurs and metatibia which are strongly curved in Bidessine fashion. Across the rear of the head is a relatively wide band of small setiferous punctures which are otherwise only present in the much larger *N. darlotensis,* which was found in the same bore hole.

Nirripirti milgunensis sp. nov.

Types

Holotype: m: 'BES 8661 Milgun Station, Earrie Well, 25°07'22"S; 118°05'44"E, 27/8/2001, col. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 32993. Slide mounted.

Paratypes: 4; 1, as for holotype, SAMA; 3 (1 partial), as for holotype except 'BES 8662, 28/8/2001', 2 (1 partial) WAM 32994–32995, 1 SAMA.

Description (number examined, 5) Figs 103–108

Habitus. Length 1.2–1.3 mm; elongate, almost parallel-sided, relatively flat, very weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, reduced to tiny flap.

Head. Large, nearly as wide as elytra; smooth, moderate reticulation with small even meshes, virtually impunctate except a few near antennae bases; subparallel in posterior half; eye remnant absent. Antenna stout, segment 1 cylindrical, segment 2 large oval, segments 3 to 5 thinner than rest, segment 11 about 1.5 times as long as segment 10. Maxillary palpus stout, segment 4 much longer than segment 3.

Pronotum. About as wide as elytra; anteriolateral angles projecting strongly forward, sides straight, base not constricted, posterolateral angles obtuse; quite strongly reticulate, virtually impunctate except towards front margin; some long setae at side towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, parallel-sided, smooth, covered with strong reticulation; a few scattered small punctures; additional larger punctures with long setae, more frequent towards sides; setiferous micropunctures over most of underside denser near base, at apex and along suture line. Epipleuron not differentiated, that part of elytron visible ventrally broad in anterior fifth, then progressively narrowing to near apex.

Ventral surface. Prosternal process relatively narrow, strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, tip pointed, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum broadly pointed in front in midline; wings short, narrow; bluntly triangular in midline behind.

Metacoxal plates large, metacoxal lines absent; virtually impunctate; moderately reticulate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct in inner half indistinct laterally, ventrites 3 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Profemur relatively stout; protibia narrow, widest at apex where it is about three times its basal width; protarsi quite strongly expanded, segment 1 broadly triangular, segment 2 not much shorter that segment 1, segment 3 as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, broadening towards apex, a little curved, about length of segment 3; segments 1 to 3 a little asymmetric with the outer lobe larger than inner, with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate/oval with a few fine setae at apex; mesofemur with row of four to five strong spines along hind edge in basal half; mesotarsi much less expanded than protarsi. Metatrochanter large, oval, tip separated from metafemur; metafemur stout, lacking spines; swimming-hairs sparse; metatibia weakly curved, widening slightly towards apex; metatarsi stout, elongate, impunctate, segment 1 longest, segment 5 twice the length of segment 4, segments 2 and 3 subequal, segments 1 and 2 in combination about as long as others, segments 2 to 5 without spines other than at apex; claws weak.

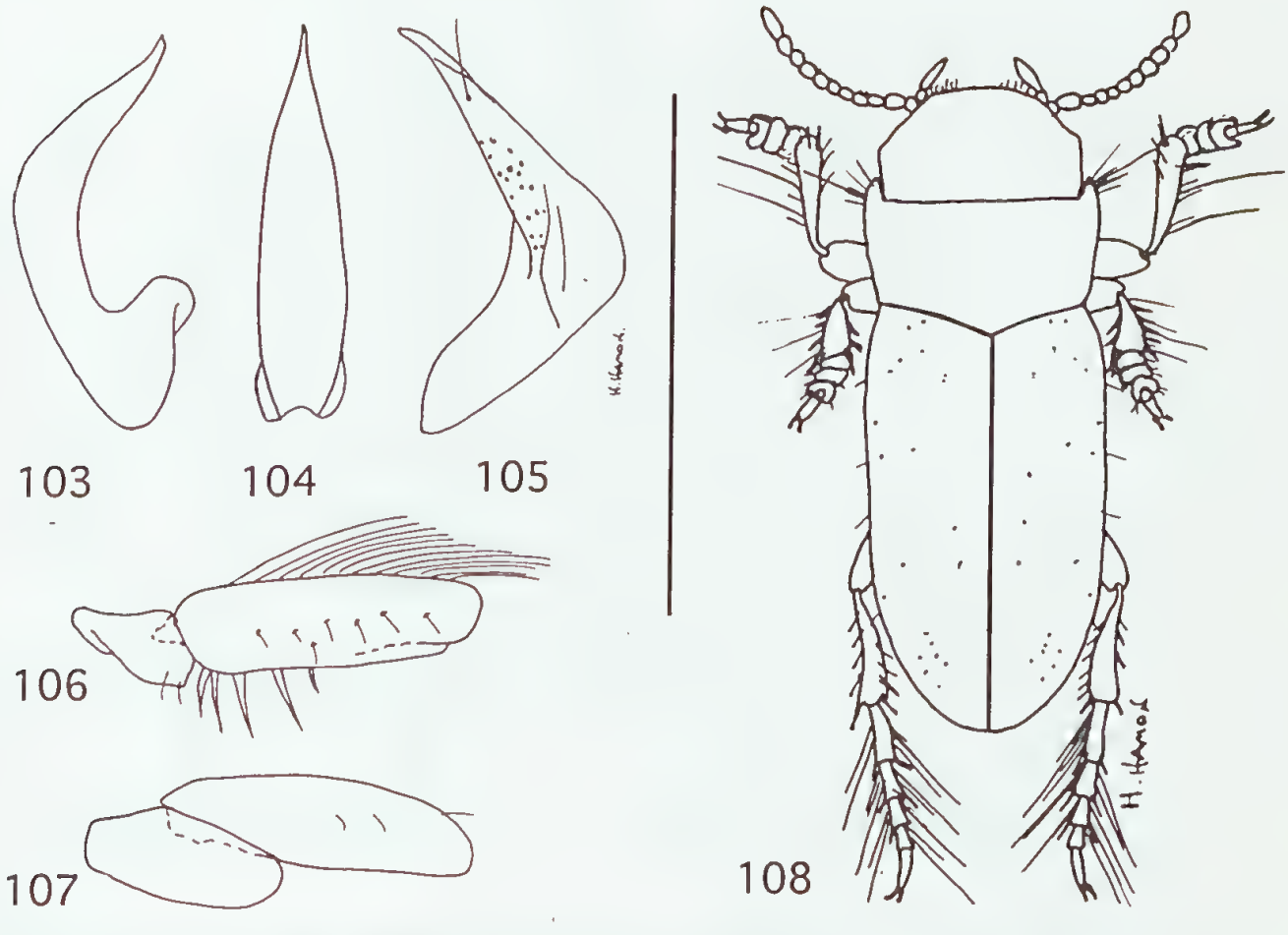
Male. Little difference from female. Median lobe of aedeagus narrowing rapidly in apical quarter; paramere broad at base, apical half thin, tip with a bunch of long setae (Figs. 103–105).

Etymology

Named after the pastoral station on which it was found.

Remarks

A very small species, virtually lacking any trace of an eye remnant, pronotum not constricted, strong spines on the mesofemur, large metatrochanters, and metatarsal segment 4 only about one-half the length of segment 3.



FIGURES 103–108. *Nirripirti milgunensis*: **103**, lateral view of central lobe of aedeagus; **104**, ditto dorsal view; **105**, paramere; **106**, mesotrochanter and mesofemur; **107**, metatrochanter and metafemur; **108** dorsal view. Scale bar represents 1 mm (habitus only).

Nirripirti napperbyensis sp. nov.

Types

Holotype: m: 'BES 8091. NT: Napperby Station., Bore RN 1561 at Herbert Well, 22°54'32"S 132°43'45"E, 17/6/2001, Col. W.F. Humphreys & R. Read', NTM I 001175. Slide mounted.

Paratypes: 7; 5, as for holotype, 2 WAM 32996–32997, 3 SAMA; 2, as for holotype except 'BES 8090', WAM 32998–32999.

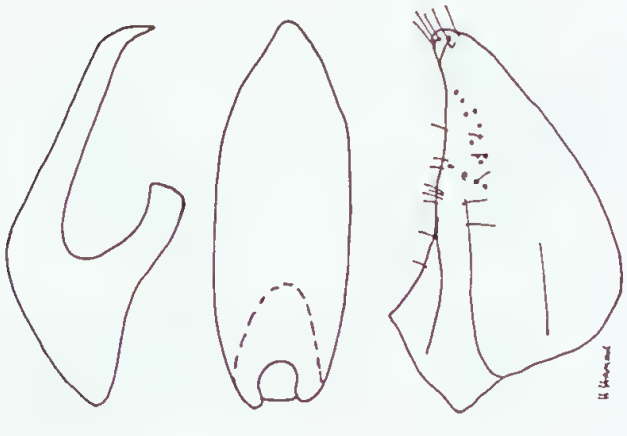
Description (number examined, 8) Figs 109–114

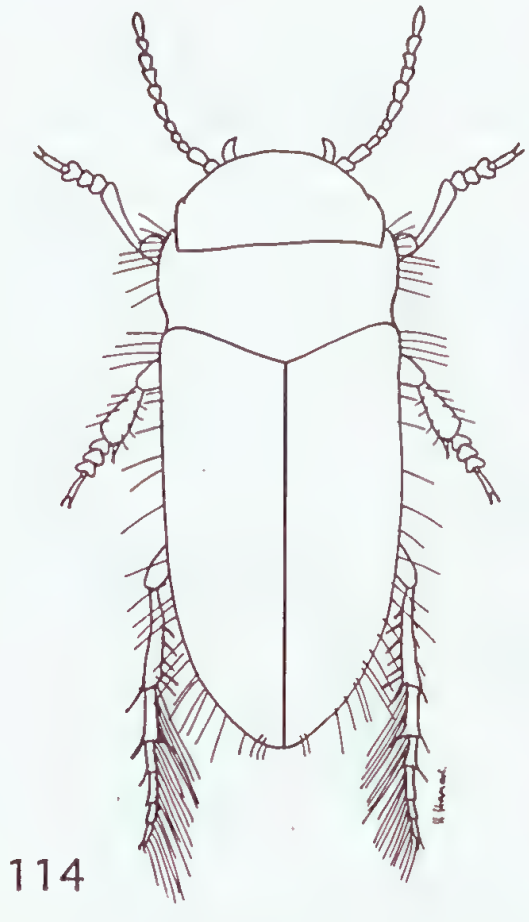
Habitus. Length 1.7–1.8 mm; elongate, relatively flat, weakly constricted at junction of pronotum/elytra; light testaceous, head a little darker; hindwing vestigial, reduced to tiny flap.

Head. Large, broad, a little narrower than elytra; smooth, very weakly reticulate, a few very small scattered punctures; sides slightly converging towards rear; eye remnant reduced to a very short suture Antenna relatively thick, segment 1 cylindrical, segment 2 enlarged towards apex, segments 3 and 4 much shorter and thinner, segments 5 to 10 similar in shape, middle ones slightly larger, segment 11 about twice as long as segment 10. Maxillary palpus stout, elongate, segment 4 twice as long as segment 3, some long setae towards apex of segments.

Pronotum. Almost same width as elytra; anteriolateral angles projecting strongly forward; sides weakly curved, weakly constricted before base; posterolateral angles acute; weakly reticulate, sparse small punctures, larger punctures laterally, denser towards front; long setae at sides in anterior half.

Elytra. Not fused, lacking inner ridges; elongate, widest behind middle, smooth, very weakly reticulate, a few scattered small punctures, several loose rows of widely spaced small punctures, a few additional larger punctures with long setae; underside of elytron with numerous evenly spaced setiferous micropunctures more frequent towards sides and denser towards apex.





FIGURES 109–114. *Nirripirti napperbyensis*: **109**, lateral view of central lobe of aedeagus; **110**, ditto dorsal view; **111**, paramere; **112**, mesotrochanter and mesofemur; **113**, metatrochanter and metafemur; **114** dorsal view. Scale bar represents 1 mm (habitus only).

Epipleuron not differentiated, that part of elytron visible ventrally present only at extreme base.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half broad, diamond shaped, tip sharply pointed, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternal plate bluntly pointed in front in midline; wings short, narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines weak, well separated, diverging in anterior half, not reaching metasternum; virtually impunctate, weakly reticulate; closely adpressed to first abdominal ventrite. Ventrites fused, sutural lines distinct in inner half absent laterally, ventrites 3 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Protibia narrow, widest near apex where it is about twice its basal width; protarsi moderately expanded, segment 1 broadly triangular, segment 2 about one-half length of segment 1, segment 3 as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about 1.5 times length of segment 3, segments 1 to 3 with adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of four strong setae/spines along hind edge in basal half; mesotarsi narrower and longer than protarsi. Metatrochanter relatively large, oval, apex well separated from metafemur; metafemur relatively stout, lacking spines; metatibia weakly curved, widening slightly towards apex; metatarsi with segment 1 longest, segment 4 shortest, in combination segments 1 and 2 much shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Little external difference between the sexes. Median lobe of aedeagus short, flat, narrowing rapidly to sharp tip; paramere broad, apical half relatively broad, apex rounded (Figs 109–111).

Etymology

Named after the type locality.

Remarks

A moderately sized Northern Territory species with the ventrally visible parts of the elytra very short, and a broad pronotal process with a relative long sharp tip.

Nirripirti newhavenensis sp. nov.

Types

Holotype: m: 'BES 6681: NT: Newhaven Station, bore RN 12787; 22°43'41"S; 131°09'59"E; 15/6/2001. Col. W.F. Humphreys & A. Russ', NTM I 001176. Slide mounted.

Paratypes: 9; 4, as for holotype, 2 WAM 33000–33001, 2 SAMA; 2, ditto except 'BES 6665' WAM 33002–33003; 3, as for holotype except 'BES 6680', 1 WAM 33004, 2 SAMA.

Description (number examined, 10) Figs 115–120

Habitus. Length 1.5–1.7 mm; elongate, relatively flat, moderately constricted at junction of pronotum/elytra; uniformly very light testaceous; hindwing vestigial, reduced to tiny flap.

Head. Large, broader than long, nearly as wide as elytra; smooth, a few scattered small punctures, moderately reticulate; sides subparallel in posterior half; eye remnant reduced to a short broad suture in middle near side. Antenna stout, segment 1 wide cylindrical, segment 2 large oval, segments 3 and 4 much shorter and narrower, segments 5 and 6 approximately the same shape but narrower at base, segments 7 to 8 same shape becoming progressively slightly narrower, segment 11 nearly twice as long and about same width as segment 10. Maxillary palpus elongate, segment 4 longer than segment 3, some long setae towards apex of segments.

Pronotum. About as wide as elytra; anteriolateral angles projecting strongly forward; base moderately narrowed, posterolateral angles obtuse; moderately reticulate, virtually impunctate except for some relatively strong punctures towards sides and front margin. Long setae at sides particularly towards the front.

Elytra. Not fused, lacking inner ridges; elongate, sides narrowing slightly towards apex, smooth, moderately reticulate, disc covered with moderately sized punctures, absent at sides; a few additional larger punctures with long setae, more frequent towards sides; setiferous micropunctures over much of underside of elytron except towards sides. Epipleuron not differentiated, that portion of elytron visible ventrally relatively broad for all but apical portion of elytron.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly pointed in front in

midline; wings very short; broadly rounded in midline behind. Metacoxal plates large, reaching episternum, metacoxal lines absent; moderately reticulate, virtually impunctate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct, ventrites 3 to 5 mobile, virtually impunctate except for a few long central setae or bunch of long setae.

Legs. Protibia narrow, widest at apex where it is about twice its basal width; protarsi quite strongly expanded, segment 1 broadly oval, segment 2 about one-half length of segment 1, segment 3 as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about 1.5 times length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter narrowly oval with a few fine setae at apex; mesofemur with row of four to five strong spines along hind edge in basal half; mesotarsi not expanded, much narrower and longer than protarsi. Metatrochanter large, bluntly pointed, apex well separated from metafemur; metafemur relatively broad, lacking spines; metatibia weakly curved, widening slightly towards apex; metatarsi relatively stout, segment 1 longest, segment 4 shortest, in combination segments 1 and 2 much shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

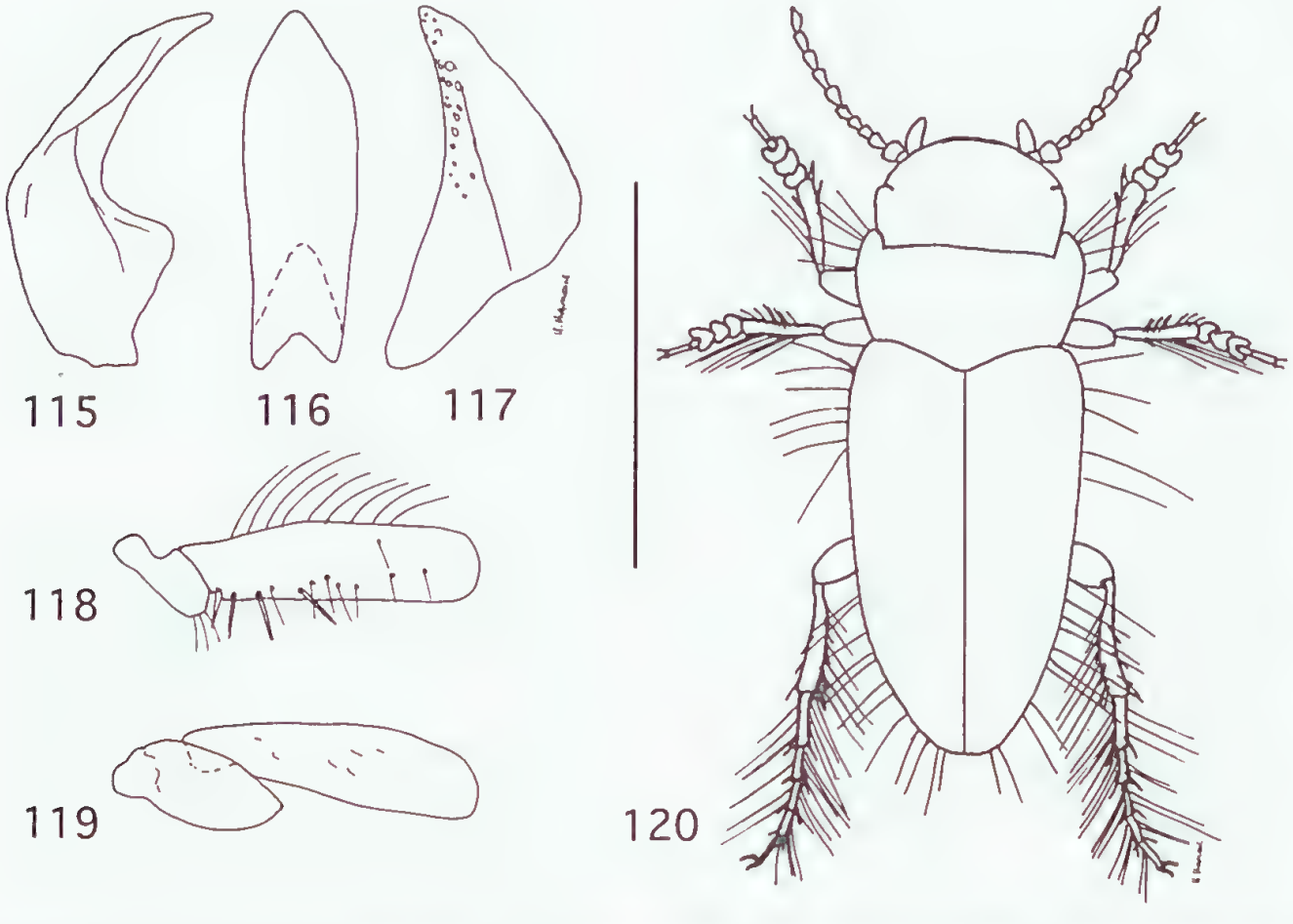
Male. Little difference from female. Median lobe of aedeagus narrowing rapidly in apical quarter; paramere relatively broad, apex blunt (Figs 115–117).

Etymology

Named after the type locality.

Remarks

A relatively small, lightly chitinised species with a large second antennal segment and the sides of the elytra wrapping over the abdomen for most of their length. Separated from the relatively similar *N. wedgeensis* by its larger size and quite strongly constricted base of the pronotum.



FIGURES 115–120. *Nirripirti newhavenensis*: **115**, lateral view of central lobe of aedeagus; **116**, ditto dorsal view; **117**, paramere; **118**, mesotrochanter and mesofemur; **119**, metatrochanter and metafemur; **120**, dorsal view. Scale bar represents 1 mm (habitus only).

Nirripirti pentameres sp. nov.

Types

Holotype: m: 'BES 6687: NT: Newhaven Station, Camel Well RN 15494, 22°22'56"S 131°11'23"E, 15/6/2001, col. W.F. Humphreys & A. Russ', NTM I 001177. Slide mounted.

Description (number examined, 1) Figs 121–126

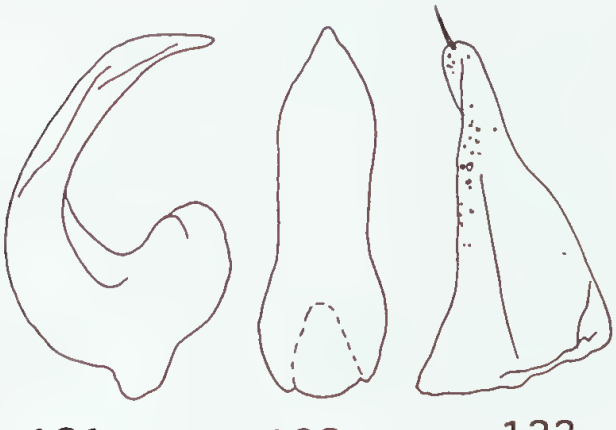
Habitus. Length 2.2 mm; elongate, relatively flat, slightly depressed in sutural region, not constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, reduced to tiny flap.

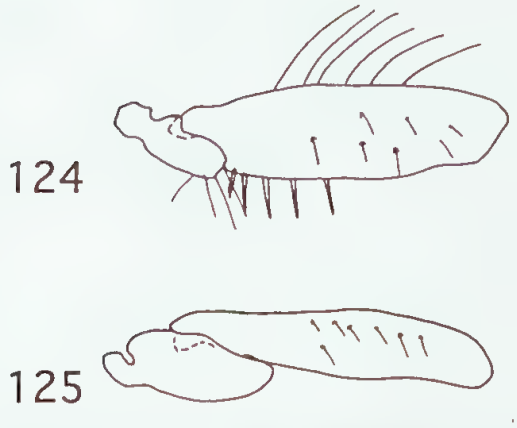
Head. Large, narrower than elytra; smooth, very weakly reticulate, scattered small punctures; sides slightly converging in posterior half; eye remnant reduced to a short suture in middle near edge. Antenna relatively thin, segment 1 stout cylindrical, segment 2 slightly oval, segments 3 and 4 much thinner and shorter, segments 5 to 10 triangular, middle segments slightly larger, segment 11 nearly twice length of segment 10. Maxillary palpus elongate, segment 4 longer than segment 3.

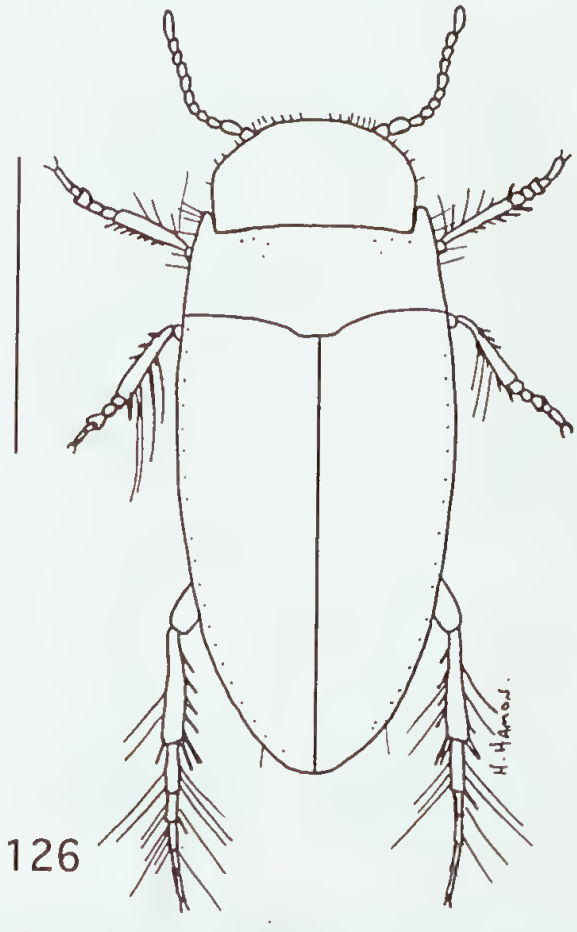
Pronotum. About as wide as elytra; anteriolateral angles projecting strongly forward; sides weakly diverging posteriorly, not narrowed at base, posterolateral angles acute; scattered small punctures denser at sides; some long setae at sides in anterior half.

Elytra. Not fused, lacking inner ridges; elongate, widest in middle, smooth, a few scattered small punctures; a few additional larger punctures with long setae, more frequent towards sides; underside with scattered setiferous micropunctures over most of surface, denser towards apex and along suture line. Epipleuron weakly differentiated from rest of elytron, that part of elytron visible ventrally broad in anterior quarter, then gradually narrowing to middle, virtually absent along rest of elytron.

Ventral surface. Prosternal process damaged in specimen, Mesocoxae in contact at midline. Metasternum sharply pointed in front in midline; wings very narrow; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; with sparse uniform covering of small punctures; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines







FIGURES 121–126. *Nirripirti pentameres*: **121**, lateral view of central lobe of aedeagus; **122**, ditto dorsal view; **123**, paramere; **124**, mesotrochanter and mesofemur; **125**, metatrochanter and metafemur; **126**, dorsal view. Scale bar represents 1 mm (habitus only).

distinct, ventrites 3 to 5 mobile, moderate number of small punctures and a few long setae or small bunch of long setae in the middle of each segment.

Legs. Protibia narrow, widest near apex where it is about twice its basal width; protarsi not expanded, segments 1 to 3 relatively small, subequal, segment 3 weakly bilobed, segment 4 about one-third length of segment 3, not hidden in lobes of segment 3, segment 5 robust, cylindrical, about twice the length of segment 3, segments 1 to 3 without adhesive setae; claws relatively strong. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of five to six strong spines along hind edge in basal half; mesotarsi similar to protarsi. Metatrochanter elongate/oval; metafemur elongate, lacking spines; metatibia weakly curved, approximately the same width throughout; metatarsi elongate, segment 1 longest, segment 4 shortest, in combination segments 1 and 2 a little shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Female unknown. Median lobe of aedeagus short, broad, flat with sharp tip; paramere with relatively broad apical half, apex rounded (Figs 121–123).

Etymology

Latin. 'Penta meres' – five segments; based on its obviously five-segmented protarsus.

Remarks

A moderate sized, distinctive species, with narrow protibia, small head and no constriction at the junction of pronotum and elytra. The pro- and mesotarsi are elongate, cylindrical, with the third segment only weakly bifid, exposing the relatively large fourth segment. This trend is also apparent in other Northern Territory *Nirripirti* but is more pronounced in this species.

Nirripirti plutonicensis sp. nov.

Types

Holotype: m: 'BES 8606; Three Rivers Station, bore MB4 Plutonic Borefield; 25°16'43"S 119°11'00"E; 26/8/2001. coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', WAM 33005. Slide mounted.

Paratypes 97; 11, as for holotype, 4 WAM 33006–33009, 5 SAMA; 8, 'BES 8651, Three Rivers Station, Limestone Well, 25°16'43"S 119°11'00"E, 26/8/2001, coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', 7 WAM 33010–33016, 1 SAMA; 7 ditto except 'BES 8625', 3 WAM 33017–33019, 4 SAMA; 9, 'BES 8620, Three Rivers Station, MB5, Plutonic Borefield, 25°16'43"S 119°11'00"E, 26/8/2001, coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', 5 WAM 33020–33024, 4 SAMA; 41, 'BES 8611/2, Three Rivers Station, Site 312, disused production bore, Plutonic Borefield, 25.26745°S 119.16398°E, 26/8/2001, coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', 10 WAM 33793–33802, 31 SAMA; 2, 'BES 8639, Three Rivers Station, bore MB1, Plutonic Borefield, 25.29213°S 119.18107°E, 26/8/2001, coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', SAMA; 16, 'BES 8656/7, Three Rivers Station, bore MB2, Plutonic Borefield, 25.27360°S 119.17200°E, 26/8/2001, coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', 10 WAM 33803–33812, 6 SAMA; 3 (1 partial), 'BES 8642, Three Rivers Station, new unused bore next to Gascoyne River; 25.11780°S 119.15115°E, 27/8/2001, coll. W.F. Humphreys, T. Karanovic & J.M. Waldock', SAMA.

Description (number examined, 98) Figs 127–132

Habitus. Length 3.0–3.5 mm; elongate oval, relatively flat, moderately constricted at junction of pronotum/elytra; uniformly testaceous; hindwing vestigial, reduced to tiny flap.

Head. Large about same width as pronotum; smooth, moderately strong reticulation with small even meshes, virtually impunctate except a few near antennae bases; subparallel in posterior half; eye remnant reduced to short faint suture, not always visible. Antenna relatively thin, segments 3 to 4 thinner than rest, segment 11 a bit longer and narrower than segment 10. Maxillary palpus elongate, segment 4 a little longer than segment 3.

Pronotum. A little narrower than elytra; anteriolateral angles projecting strongly forward; base weakly narrowed, posterolateral angles obtuse; quite strongly reticulate, moderate number of scattered punctures and row along front margin. Sides with numerous long setae particularly towards front.

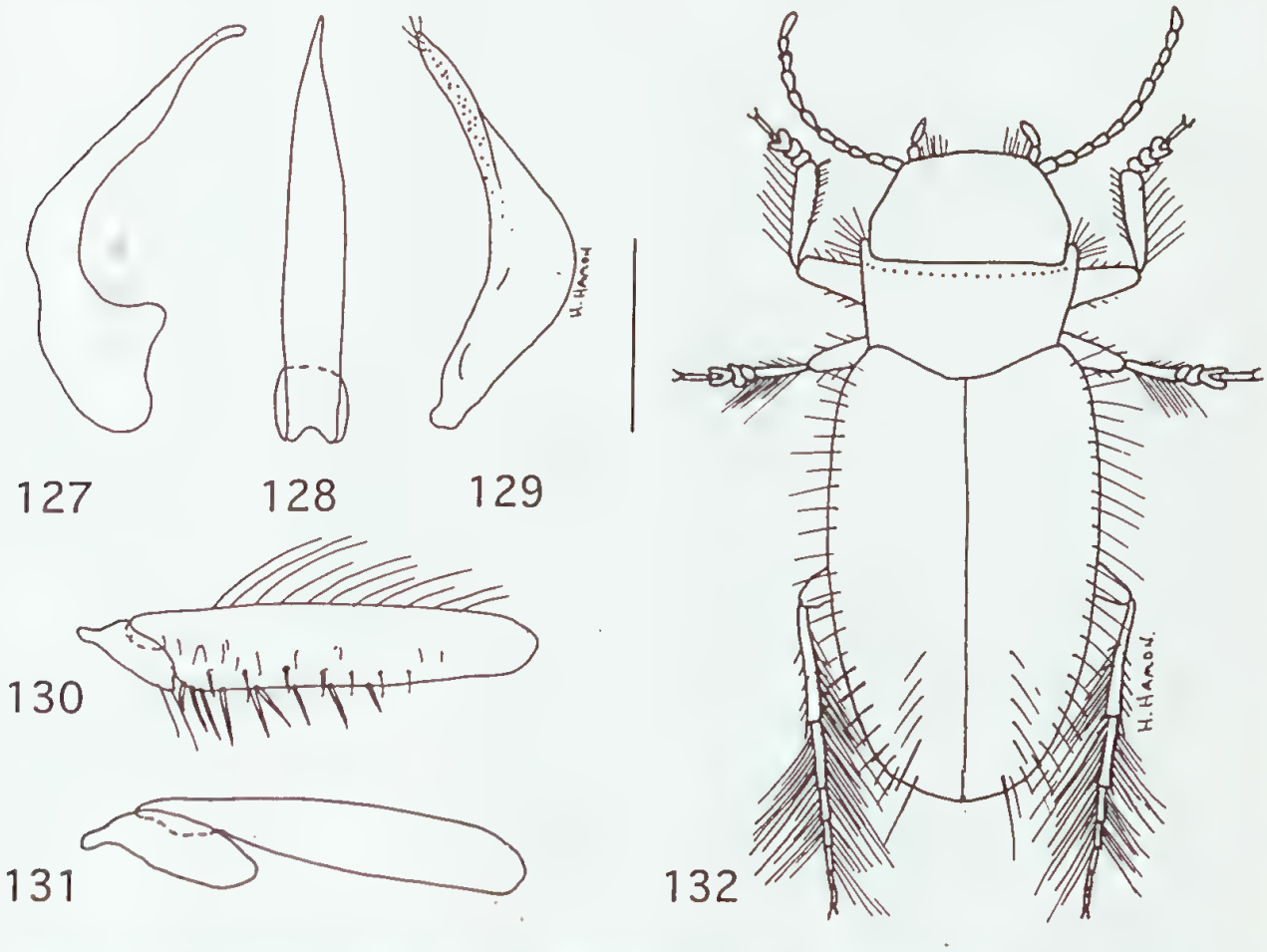
Elytra. Not fused but tightly closed, lacking inner ridges; elongate, nearly parallel-sided, smooth, covered with moderately strong reticulation; sparsely covered with small punctures, several indistinct rows of widely spaced small punctures; a few additional larger punctures with long setae, more frequent towards sides, underside covered with setiferous micropunctures, denser towards apex and along suture line. Epipleuron not

differentiated from rest of elytron, that part of elytron visible ventrally broad in anterior fifth, then rapidly narrowing to middle.

Ventral surface. Prosternal process quite narrow, strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, tip rounded; strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum bluntly pointed in front in midline; wings absent; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate; strongly reticulate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct in inner half indistinct laterally, ventrites 3 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Profemur with weak peg-like seta on hind edge adjacent to trochanter; protibia narrow, almost parallel-sided in apical half; protarsi expanded, segment 1 broad, segment 2 about one-half length of segment 1, segment 3 as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of six to eight strong spines along hind edge in basal half; mesotarsi a little less expanded than protarsi. Metatrochanter elongate/oval; metafemur thin, elongate, lacking spines; metatibia very weakly curved, approximately the same width throughout; metatarsi elongate, segment 1 much longer than others, segment 5 about 1.5 times length of segment 4, segments 2 and 3 subequal in length, segments 1 and 2 in combination a little longer than others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Little external difference between sexes. Median lobe of aedeagus sinuate in lateral view, narrowing to sharp point in apical half; paramere broad at base, apical half thin, tip with a bunch of long setae (Figs 127–129).



FIGURES 127–132. *Nirripirti plutonicensis*: **127**, lateral view of central lobe of aedeagus; **128**, ditto dorsal view; **129**, paramere; **130**, mesotrochanter and mesofemur; **131**, metatrochanter and metafemur; **132**, dorsal view. Scale bar represents 1 mm (habitus only).

Etymology

Named after the borefield in which it was found.

Remarks

A large strongly chitinised species with elytra not wrapping around abdomen, without metasternal wings, long thin hind legs and narrowly oval metatrochanters.

Nirripirti skaphites sp. nov

Types

Holotype: m: 'Karalundi, unlined well, 26°08'S; 118°41'E, 28/5/2001, coll.# 339-2 C.H.S. & G.A. Watts', WAM 33813. Slide mounted.

Paratypes: 3, as for holotype, 2 SAMA, 1 WAM 33814.

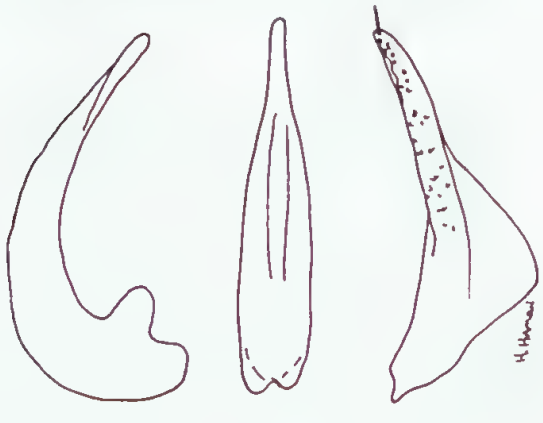
Description (number examined, 4) Figs 133–138

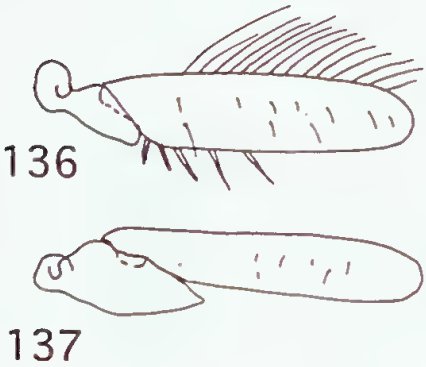
Habitus. Length 2.1–2.3 mm; elongate, boat-shaped, relatively flat, not constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, reduced to tiny flap.

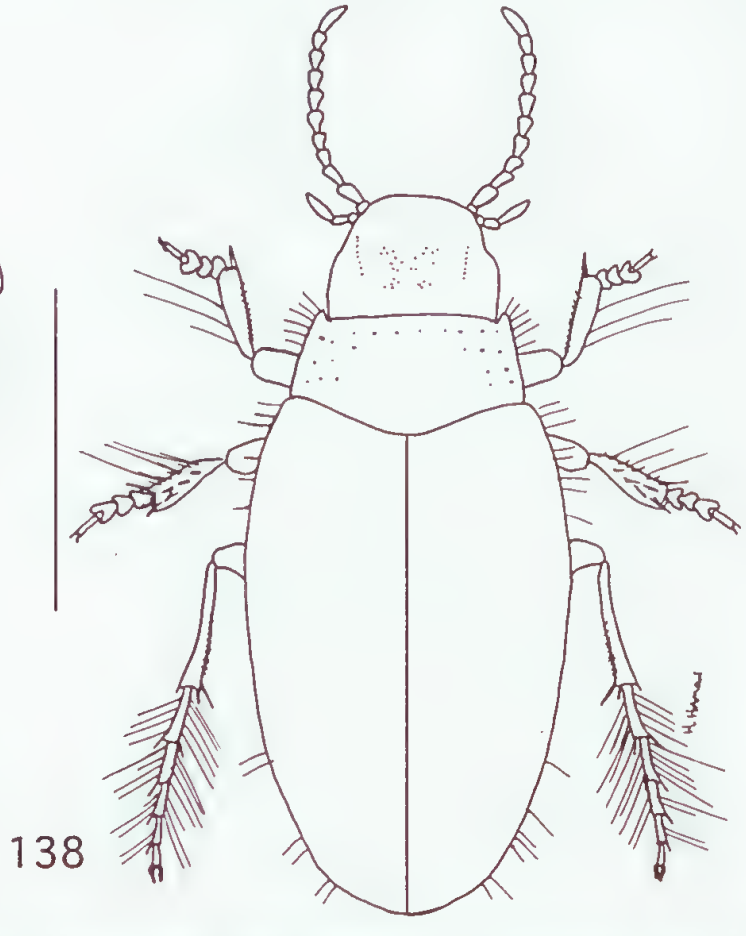
Head. Small, about half width of elytra; smooth, moderately strong reticulation with small even meshes, virtually impunctate except a few near antennae bases and on disc; sides slightly curved in posterior half; eye remnant reduced to a short suture in middle near anterior edge. Antenna moderately thick, segment 1 cylindrical, segment 2 widening towards apex, segments 3 to 10 approximately equal in length, widening progressively to segment 5, segment 11 about twice length of segment 10. Maxillary palpus elongate, segment 4 about twice length of segment 3.

Pronotum. Narrower than elytra; anteriolateral angles projecting strongly forward; sides slightly diverging towards rear; posterolateral angles obtuse; strongly reticulate, a few small scattered punctures; numerous long setae at sides towards front.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest in middle, smooth, covered with fine reticulation; a few scattered small punctures, underside with a few setiferous micropunctures at apex, a few additional larger punctures with long setae, more frequent towards







FIGURES 133–138. *Nirripirti skaphites*: **133**, lateral view of central lobe of aedeagus; **134**, ditto dorsal view; **135**, paramere; **136**, mesotrochanter and mesofemur; **137**, metatrochanter and metafemur; **138**, dorsal view. Scale bar represents 1 mm (habitus only).

sides. Epipleuron not differentiated, that part of elytron visible ventrally very broad until close to apex of elytron.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half broadly spatulate, weakly pointed, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum pointed in front in midline; wings short; broadly rounded in midline behind. Metacoxal plates large, metacoxal lines absent; a few small scattered very small punctures; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct in inner two-thirds but absent laterally, ventrites 3 to 5 possibly immobile, virtually impunctate except for a few long central seta or bunch of long setae.

Legs. Protibia narrow, widest near apex where it is about twice its basal width; protarsi weakly expanded, segment 1 rectangular, segment 2 about one-half length of segment 1, segment 3 about as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about twice length of segment 3, segments 1 to 3 with covering of adhesive setae; claws short and simple. Mesotrochanter elongate, rather angular, with a few fine setae at apex; mesofemur with row of five to six strong spines along hind edge in basal half; mesotarsi slightly less expanded than protarsi. Metatrochanter relatively broad, sharply pointed; metafemur elongate, lacking spines; metatibia weakly curved, widening a little towards apex; metatarsi elongate, segment 1 longest, segment 4 shortest, in combination segments 1 and 2 same length as others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Antenna a little stouter. Median lobe of the aedeagus narrow, narrowing in apical quarter; paramere broad at base, apical half thin, tip with a long setae (Figs 133–135).

Etymology

Latin. 'Skaphites' – boat-like.

Remarks

A moderate sized species with small head and no pronotal constriction, which give it a pronounced boat-like shape. The sharply pointed metatrochanters are also distinctive and separate it from the rather similarly shaped but smaller *N. killaraensis.*

Nirripirti stegastos sp. nov.

Types

Holotype: m: 'Karalundi, un-lined well; 6°08'S; 118°41'E, 28/5/2001, coll. C.H.S. & G.A. Watts', WAM 33815.

Paratypes: 2, as for holotype, 1 WAM 33816, 1 SAMA.

Description (number examined, 3) Figs 139–144

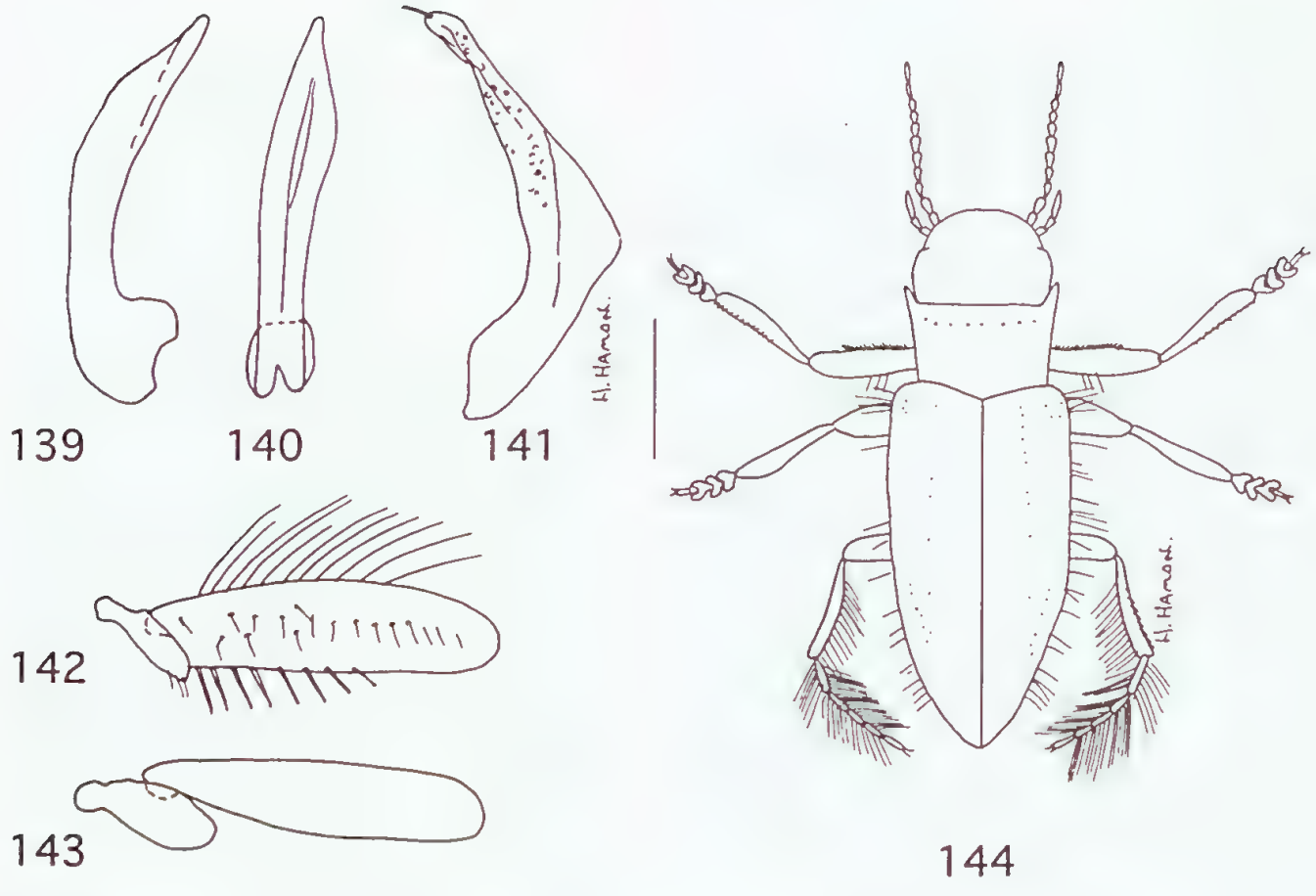
Habitus. Length 3.6–3.8 mm; elongate, relatively flat, slightly depressed in sutural region, weakly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, reduced to tiny flap.

Head. A little narrower than elytra; smooth, moderate reticulation with very small even meshes, a few scattered small punctures; sides subparallel in posterior half; eye remnant reduced to a small suture in middle near anterior edge. Antenna thin, segments 1 and 2 cylindrical, segment 3 about same length as segment 2 but much narrower, segment 4 a little shorter, segments 5 to 9 broader with narrow bases, segment 6 widest, segment 11 1.5 times length of segment 10. Maxillary palpus elongate, segment 4 a little longer than segment 3.

Pronotum. A little narrower than elytra; anteriolateral angles projecting strongly forward; sides slightly converging towards rear, weakly constricted just before base, posterolateral angles obtuse; weakly reticulate, virtually impunctate except for a row of strong punctures along front margin; long setae at sides in anterior third; moderately strongly reticulate with very small even meshes.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, almost parallel-sided, smooth, covered with fine reticulation; virtually impunctate except for a few moderate sized punctures with long setae, more frequent towards sides; underside of elytron with dense setiferous micropunctures towards apex. Epipleuron very weakly differentiated from rest of elytron, that part of elytra visible ventrally very broad along almost the entire length of elytron, tightly enclosing body.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching mesothorax, apical half narrowly triangular, tip rounded, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum not produced forward in midline; wings relatively short, very narrow; broadly rounded in midline



FIGURES 139–144. *Nirridessus stegastos*: **139**, lateral view of central lobe of aedeagus; **140**, ditto dorsal view; **141**, paramere; **142**, mesotrochanter and mesofemur; **143**, metatrochanter and metafemur; **144**, dorsal view. Scale bar represents 1 mm (habitus only).

behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct in inner half, indistinct laterally, ventrites 2 and 3 possibly fused, ventrites 4 to 5 mobile, virtually impunctate except for a few long central seta or bunch of long setae; finely reticulate with small even meshes.

Legs. Protibia very narrow, widest just past middle where it is about twice its basal width; protarsi expanded, segment 1 short, broadly triangular, segment 2 about one-half length of segment 1, segment 3 about as long as segment 1 but narrower, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, relatively stout, about length of segment 3, segments 1 to 3 with dense covering of adhesive setae; claws short and simple. Mesotrochanter elongate, bluntly pointed, with a few fine setae at apex; mesofemur with row of nine strong spines along hind edge in basal two-thirds; mesotarsi a little narrower and more elongate than protarsi. Metatrochanter moderately large, elongate/oval apex rounded; metafemur elongate, lacking spines; metatibia weakly curved, widening slightly towards apex; metatarsi elongate, segment 1 longest, segment 4 shortest, in combination segments 1 and 2 slightly shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

Male. Middle segments of antenna a little more expanded than in the female. Median lobe of aedeagus narrow, narrowing in apical quarter; paramere narrowing in apical half, apex rounded (Figs 139–141).

Etymology

Latin. 'Stegastos' – enclosed; a reference to the enclosing elytra.

Remarks

A relatively large well chitinised species with the elytra wrapping around the abdomen for most of its length.

Nirripirti wedgeensis sp. nov.

Types

Holotype: m: 'BES 8066, NT: Central Mt Wedge Station, bore RN 15504 at Coppocks Bore, 22°46'24"S 132°06'50"E, 17/6/2001, coll. W.F. Humphreys & R. Read', NTM I 001178. Slide mounted.

Paratypes: 5, as for holotype, 2 WAM 33817–33818, 3 SAMA.

Description (number examined, 6) Figs 145–150

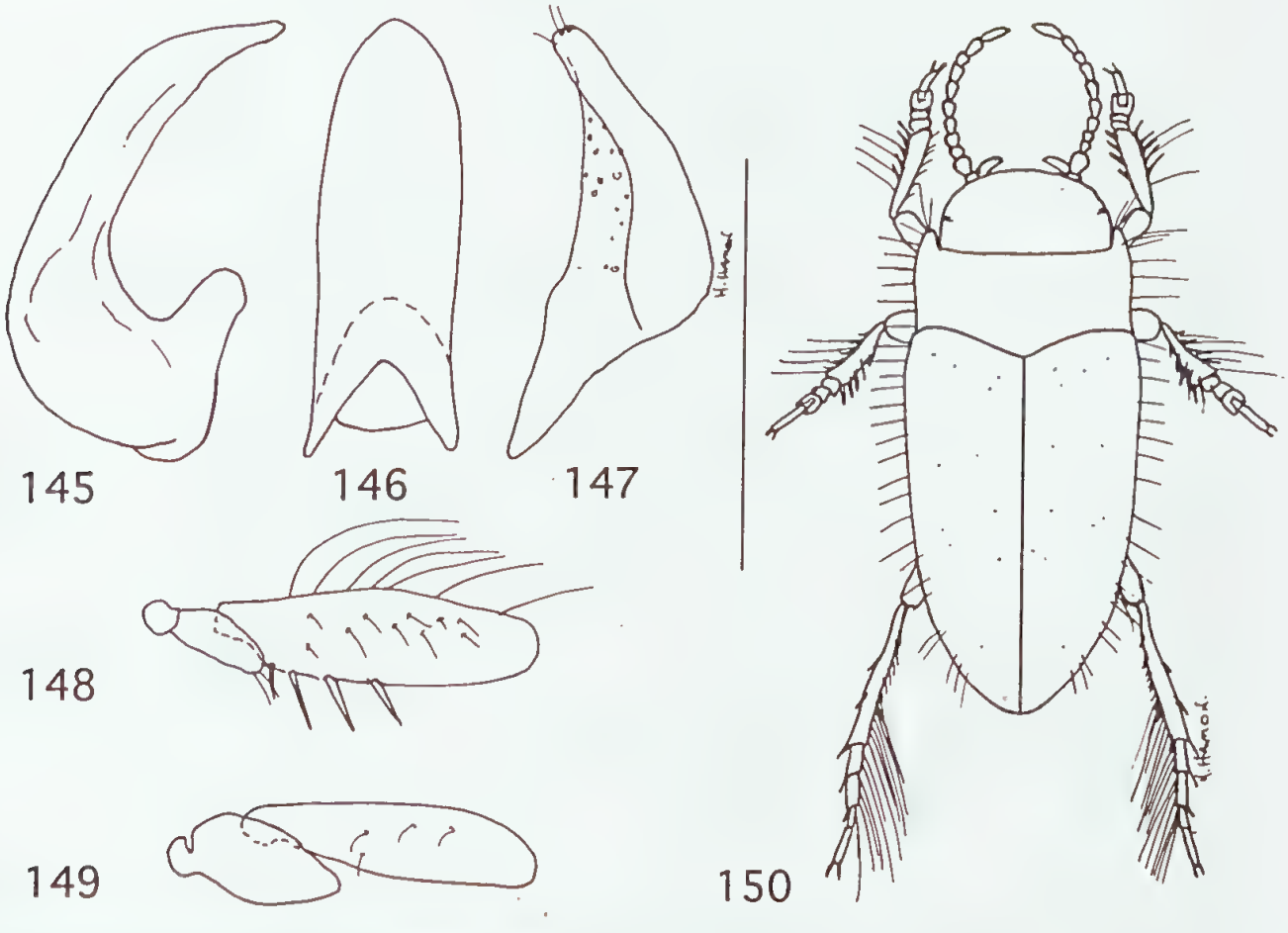
Habitus. Length 1.2–1.4 mm; elongate, relatively flat, slightly constricted at junction of pronotum/elytra; uniformly very light testaceous; hindwing vestigial, reduced to tiny flap.

Head. Short, broad, narrower than elytra; smooth, moderate reticulation with small even meshes, virtually impunctate except a few near antennae bases; slightly wider behind; eye remnant reduced to a dark suture in middle near anterior edge. Antenna relatively thick, segment 1 cylindrical, segment 2 broader towards apex, segment 3 much shorter and narrower, segment 4 shorter, segment 5 about same length as segment 3 but wider, segments 6 to 10 subequal, becoming progressively a little narrower, segment 11 about twice length of segment 10. Maxillary palpus stout, segment 4 about twice as long as segment 10.

Pronotum. As wide as elytra; anteriolateral angles projecting strongly forward; base weakly constricted, posterolateral angles acute; moderately reticulate, virtually impunctate except towards front margin.

Elytra. Not fused but tightly closed, lacking inner ridges; elongate, widest near shoulders, smooth, reticulation weak; numerous scattered small punctures; a few additional larger punctures with long setae, more frequent towards sides; underside with numerous setiferous micropunctures at base, apex and along suture line. Epipleuron not differentiated from rest of elytron, that part of elytron visible ventrally broad in anterior quarter, then gradually narrowing to near apex.

Ventral surface. Prosternal process strongly narrowed between coxae, not reaching



FIGURES 145–150. *Nirridessus wedgeensis*: **145**, lateral view of central lobe of aedeagus; **146**, ditto dorsal view; **147**, paramere; **148**, mesotrochanter and mesofemur; **149**, metatrochanter and metafemur; **150**, dorsal view. Scale bar represents 1 mm (habitus only).

mesothorax, apical half broad, spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metasternum sharply pointed in front in midline; wings absent; broadly triangular in midline behind. Metacoxal plates large, metacoxal lines absent; virtually impunctate; closely adpressed to first abdominal ventrite. Ventrites 1 and 2 fused, sutural lines distinct, ventrites 3 to 5 mobile, virtually impunctate except for a few long central setae or bunch of long setae.

Legs. Profemur broad; protibia narrow, widest near apex where it is about three times its basal width; protarsi expanded, segment 1 broadly triangular, segment 2 about one-half length of segment 1, segment 3 as long as segment 1, deeply bifid, segment 4 very small and hidden within lobes of segment 3, segment 5 narrow, cylindrical, about length of segment 3, segments 1 to 3 with covering of adhesive setae; claws short and simple. Mesotrochanter elongate with a few fine setae at apex; mesofemur with row of four to five strong spines along hind edge in basal half; mesotarsi a little less expanded than protarsi. Metatrochanter relatively large, tip well separated from metafemur, bluntly pointed; metafemur elongate, lacking spines; metatibia curved, approximately the same width throughout; metatarsi elongate, segments 1 and 5 longest, subequal, segments 1 and 2 in combination much shorter than others, segments 2 to 5 without spines other than at apex; claws weak.

TABLE 1. The distribution of stygal species of dytiscids amongst discrete calcrete bodies in the Yilgarn district of Western Australia and the Ngalia Basin in the Northern Territory. The separate palaeodrainage systems (Fig. 151) and the Indian Ocean (Western) and inland drainages are indicated.

Calcrete	Palaeovalley	Species 1
	WESTERN DRAINAGES	
1, Cue	Murchison	*Tjirtudessus magnificus*
2, Austin Downs	Murchison	*Tjirtudessus challaensis*
3, Challa North	Murchison	*Tjirtudessus challaensis*
4, Killara	Murchison	*Nirripirti killaraensis* sp nov.
5, Windimurra	Murchison	*Tjirtudessus* sp. 1
6, Karalundi	Murchison	*Tjirtudessus karalundiensis* sp. nov.
7, Three Rivers Station	Gascoyne	*Bidessodes gutteridgei* sp. nov.
8, Milgun Station	Gascoyne	*Nirripirti hamoni* sp. nov.
9, Landor Station	Gascoyne	
	INLAND DRAINAGES	
10, Paroo	Carey	*Tjirtudessus eberhardi*
11, Lake Violet	Carey	*Tjirtudessus wilunaensis* sp. nov
12, Uramurdah Lake	Carey	*Tjirtudessus hahni*
13, Hinkler Well	Carey	*Tjirtudessus hinkleri*
14, Mount Windarra	Carey	*Tjirtudessus windarraensis*
15, Melrose Station (Lake Darlot)	Carey	*Nirripirti darlotensis* sp. nov.
16, Depot Springs	Raeside	*Tjirtudessus fridaywellensis*
17, Pinnacles Stn	Raeside	*Tjirtudessus pinnaclesensis*
18, Lake Mason	Raeside	*Tjirtudessus raesideensis*
19, Yuinmery	Raeside	*Tjirtudessus yuinmeryensis* sp. nov.
20, Jundee	Carnegie	*Tjirtudessus jundeeensis* sp. nov.
21, Cunyu: Sweetwaters	Nabberu	*Tjirtudessus cunyuensis* sp. nov
22, Cunyu: SBF	Nabberu	*Tjirtudessus bialveus* sp. nov.
23, Napperby	Ngalia Basin: NT	*Nirripirti macrocephalus* sp nov.
24, Newhaven	Ngalia Basin: NT	*Nirripirti newhavenensis* sp. nov.
25, Central Mount Wedge	Ngalia Basin: NT	*Nirripirti wedgeensis* sp nov.

Male. Little external difference from female. Median lobe of aedeagus broad, bluntly pointed; paramere triangular (Figs 145–147).

Etymology

Named after Central Mount Wedge pastoral station where it was collected.

Remarks

A very small almost parallel-sided species with the base of the elytra noticeably wider than the pronotum, which is only slightly constricted. Separated from the slightly larger *N. newhavenensis* from an adjacent calcrete by the weakly constricted pronotum.

Discussion

Associated fauna

The faunas associated with the Dytiscidae are largely unworked at this stage with only the Copepods having been studied in detail. Hence, only an indication of the associated fauna is given here. As is typical of stygofaunas, the associated fauna is predominantly Crustacean including Bathynellacea (Syncarida), Crangonyctoidea, Ceinidae and Bogidiellidae (Amphipoda), Oniscidea (Isopoda, including *Haloniscus* spp.), Cyclopoida: Cyclopidae; Harpacticoida: Diosacchidae, Ameiridae, Canthocamptidae

Species 2	Species 3	Species 4
Tjirtudessus cueensis		
Tjirtudessus cueensis	*Tjirtudessus bigbellensis*	*Tjirtudessus* sp. 3
Tjirtudessus sp. 2		
Nirripirti skaphites sp. nov.	*Nirripirti stegastos* sp. nov.	
Bidessodes limestoneensis sp. nov.	*Nirripirti hamoni* sp nov.	*Nirripirti plutonicensis* sp. nov.
Nirripirti milgunensis sp. nov.		
Tjirtudessus pulpa	*Kintingka kurutjutu*	
Tjirtudessus morgani		
Tjirtudessus morgani		
Undescribed		
Tjirtudessus lapostaae		
Nirripirti melroseensis sp. nov.		
Nirripirti hinzeae		
Nirripirti fortisspina sp nov	*Nirripirti*. Undescribed sp.	? *Nirripirti* larvae
Tjirtudessus masonensis		
Tjirtudessus silus sp nov.	*Tjirtudessus sweetwatersensis* sp nov.	
Tjirtudessus macrotarsus sp nov.		
Nirripirti napperbyensis sp nov.		
Tjirtudessus pentameres sp nov.		

TABLE 2. Physicochemical environment recorded for various species of stygal Dytiscidae in the genera *Bidessodes*, *Nirripirti* and *Tjirtudessus*. A single value or a range of values given. Note that the environment of all sites has not been recorded.

Species	Conductivity (mS cm^{-1})	Temp. (°C)	pH	DO (mg L^{-1})	Depth to/ of water	Calcrete
B. gutteridgei	2.38–3.54	25.1–26.6	7.18–7.96	–	5–6/7–40	Three Rivers
B. limestoneensis	2.38	25.1	7.55	–	–	Three Rivers
N. darlotensis	13.2	25.8	7.70	5.05	–	Melrose
N. fortisspina	13.37	23.6	7.43	2.67	–	Pinnacles
N. hamoni	1.66	25.1	7.78		?/0.5	Three Rivers
N. killaraensis	3.24	19.6	–	–	–	Killara calcrete
N. macrocephalus	–	–	–	–	–	Napperby, NT
N. melroseensis	13.2	25.8	7.70	5.05	?/0.5	Melrose
N. milgunensis	1.66	25.1	7.78	–	?/0.5	Three Rivers
N. napperbyensis	–	–	–	–	–	Napperby, NT
N. newhavenensis	1.98	25.1			2.67/?	Newhaven, NT
N. pentameres	–	–	–	–	–	Newhaven, NT
N. plutonicensis	1.82–11.49	25.0–26.6	7.14–7.96	–	3.5–5/11–40	Cunyu SBF
N. wedgeensis	7.11	24.7	–	–	2.5/10	Central Mount Wedge, NT
T. bialveus	6.63–11.49	25.2–26.4	7.32–7.50	–	3.5/10	Cunyu SBF
T. cunyuensis	8.55	17.2	8.30	–	8/0.5	Cunyu Sweetwater
T. jundeeensis	–	–	–	–	7/0.3	Jundee
T. macrotarsus	6.63	25.2	7.32	–	3.5/9.5	Cunyu SBF
T. silus	8.55	17.2	8.30	–	8/0.5	Cunyu Sweetwater
T. sweetwatersensis	8.55	17.2	8.30	–	8/0.5	Cunyu Sweetwater
T. wilunaensis	2.88	18.7	7.30	–	–	Millbillillie
T. yuinmeryensis	9.39–15.4	21.9–22.2	7.27–7.63	5.22–5.44	2.5/1	Yuinmery

Parastenocaridae (Copepoda) and Ostracoda. Hydrobiidae (Gastropoda) are important associates in the Ngalia Basin of the Northern Territory (Table 3); however, in the Western Fortescue Plains aquifer in the Pilbara, they occur with Spelaeogriphacea but no Dytiscidae are present (Poore & Humphreys 1998). Karanovic (2003) recently described four new genera and eight species in five families of Copepoda from the Yilgarn region of Western Australia collected as part of this study. Those indicated in Table 3 were directly associated with the dytiscids collected here. Several species of *Haloniscus* occur in some aquifers (Taiti & Humphreys 2001).

Site characteristics and water quality

As in previously reported work on Australian stygal Dytiscidae, samples were collected from a range of types of access into the groundwater calcrete aquifers (Table 1, Fig. 151), including: monitoring wells in working water borefields, sometimes within metres of functioning pumps; piezometers; aquifer exploration bores; uncased mineral exploration bores; pastoral bores; and hand dug pastoral wells, some of which would have been enlarged traditional watering places (Table 2).

Some of the sites containing stygal dytiscid are quite saline (22 g L^{-1} or greater) (Watts & Humphreys 2000) whereas others meet salinity standards for drinking water. Groundwaters in the Australian arid zone typically have high concentrations of nitrates (Jacobson 1993); those recorded in this study had a mean value of 80 mg L^{-1} nitrate (range 0–250 mg L^{-1}: Fig. 154).

Profiling various groundwaters in the Yilgarn has not only exposed a great variety of waters but has also shown that closely adjacent sites are often quite different, revealing considerable heterogeneity of groundwater (Table 4; Fig. 153).

Hydrogen sulphide is sometimes encountered in the water (or disturbed from the sediments). At Alice Well in the Austin Downs calcrete, greater than 10 ppm H_2S was recorded, far higher even than that recorded in anchialine systems containing profuse sulphur bacteria colonies (Humphreys 1999a,b).

The distribution of the groundwater fauna and

TABLE 3. Stygofauna associated with collection of various species of stygal Dytiscidae in the genera *Bidessodes*, *Nirripirti* and *Tjirtudessus* reported in this paper. Column numbers denote: 1, Syncarida; 2, Amphipoda; 3, Crangonyctoidea; 4, Ceinidae; 5, Bogidiellidae; 6, Isopoda: Oniscidea: ?Haloniscus; 7, Copepoda; 8, Harpacticoida; 9, Cyclopoida; 10, Ostracoda; 11, Other; 12, Dytiscidae; 13, Calcrete.
Species numbers denoted in column 7 Cyclopoda: Cyclopidae: Halicyclopinae: 1, *Halicyclops kieferi* Karanovic 2003; 2, *Halicyclops eberhardi* Laurentiis Pesce & Humphreys 2001; Cyclopinae: 3, *Mesocyclops brooksi* Pesce Laurentiis & Humphreys 1996; 4, *Metacyclops laurentiisae* Karanovic 2003; 5, *Fierscyclops fiersi* (Laurentiis Pesce & Humphreys 2001); 6, *Microcyclops varicans* (Sars 1863); 7, *Goniocyclops uniarticulatus* Karanovic 2003; 8, *Goniocyclops mortoni* Karanovic 2002; Harpacticoida: Diosaccidae: 9, *Schizopera austindownsi* Karanovic 2003; 10, *Schizopera jundeei* Karanovic 2003; Ameiridae: Ameirinae: 11, *Nitokra lacustris pacifica* Yeatman 1983; 12, *Haifameira pori* Karanovic 2003; Canthocamptidae: 13, *Australocamptus similis* Karanovic 2003.

	1	2	3	4	5	6	7	8	9	10	11	12	13
Bidessodes gutteridgei sp. nov.		•	•		•	•			•			*B. limestoneensis; N. plutonicensis*	Three Rivers
Bidessodes limestoneensis sp. nov.		•	•		•	•			•			*B. gutteridgei; N. plutonicensis*	Three Rivers
Nirripirti darlotensis sp. nov.	•	•		•			2, 11						Melrose Station
Nirripirti fortisspina sp. nov.		•		•			2, 3						Pinnacles
Nirripirti hamoni sp. nov.		•	•							•		*N. milgunensis*	Three Rivers
Nirridessus karalundiensis sp. nov.							4,						Karalundi
Nirripirti killaraensis sp. nov.		•	•			•	2, 6, 8						Killara
Nirripirti macrocephalus sp. nov.	•	•				•						*N. napperbyensis*	Napperby
Nirripirti melroseensis sp. nov.	•	•		•			•					*N. darlotensis*	Melrose
Nirripirti milgunensis sp. nov.		•	•							•		*N. hamoni*	Milgun
Nirripirti napperbyensis sp. nov.	•	•				•	•			•		*N. macrocephalus*	Napperby
Nirripirti newhavenensis sp. nov.						•							Napperby
Nirripirti pentameres sp. nov.						•	•				#1		Newhaven
Nirripirti plutonicensis sp. nov.		•	•		•	•			•			*B. limestoneensis; B. gutteridgei; N. plutonicensis;*	Three Rivers
Nirripirti wedgeensis sp. nov.	•										#2		Central Mount Wedge
Tjirtudessus bialveus sp. nov.	•	•		•					•			*T. macrotarsus*	Cunyu SBF
Tjirtudessus cunyuensis sp. nov.	•	•		•				•	•	•		*T. sweetwatersensis; T. silus*	Cunyu Sweetwaters
Tjirtudessus jundeeensis sp. nov.	•					•	1, 10,	•					Jundee
Tjirtudessus macrotarsus sp. nov.	•	•		•				•				*T. bialveus*	Cunyu SBF
Tjirtudessus silus sp. nov.	•	•		•				•	•	•		*T. cunyuensis; T. sweetwatersensis*	Cunyu Sweetwaters
Tjirtudessus sweetwatersensis sp. nov.	•	•		•			4, 9	•	•	•		*T. cunyuensis; T. silus*	Cunyu Sweetwaters
Tjirtudessus wilunaensis sp. nov.	•	•	•	•		•	1, 5, 7, 12, 13		•				Lake Violet
Tjirtudessus yuinmeryensis sp. nov.		•		•		•	2, 5,			•			Yummier

In column 11: #1, Hydrobiidae: Acarina: *Koenikea*? sp.; Gastropoda: Hydrobiidae aff. *Trochidrobia* n.sp. 1; #2, Gastropoda Hydrobiidae aff. *Trochidrobia* n.sp. 2

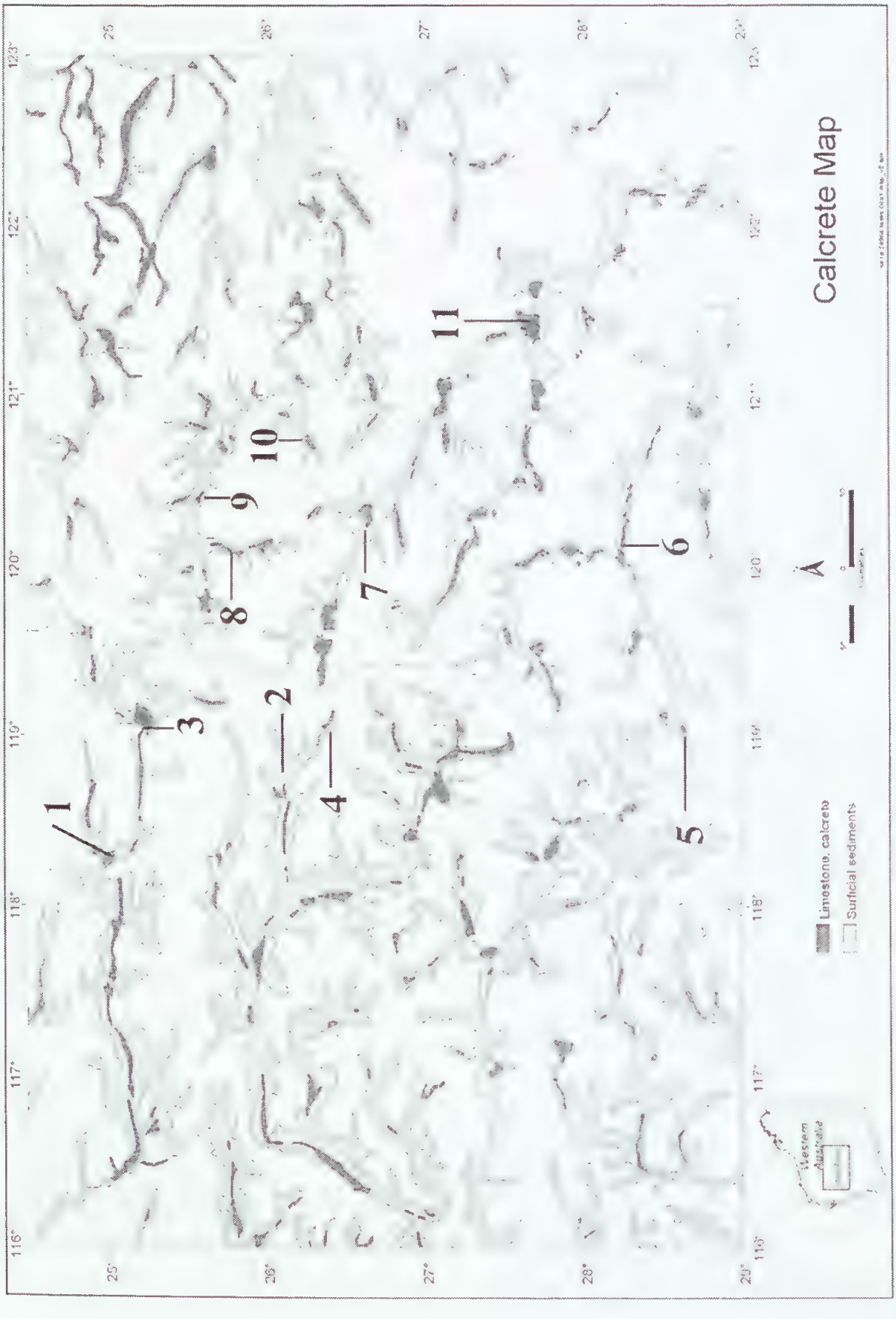


FIGURE 151. The location of calcrete areas (darker shading) and palaeodrainage systems (paler shading) in the Yilgarn region of Western Australia. Numbers proceed from west to east. **1**, Milgun calcrete; **2**, Karalundi calcrete; **3**, Three Rivers calcrete; **4**, Killara central calcrete; **5**, Yuinmery south calcrete; **6**, Pinnacles calcrete; **7**, Lake Violet calcrete; **8**, Cunyu, State Barrier Fence calcrete; **9**, Cunyu, Sweetwaters Well calcrete; **10** Jundee mine calcrete; **11**, Melrose (Lake Darlot) calcrete.

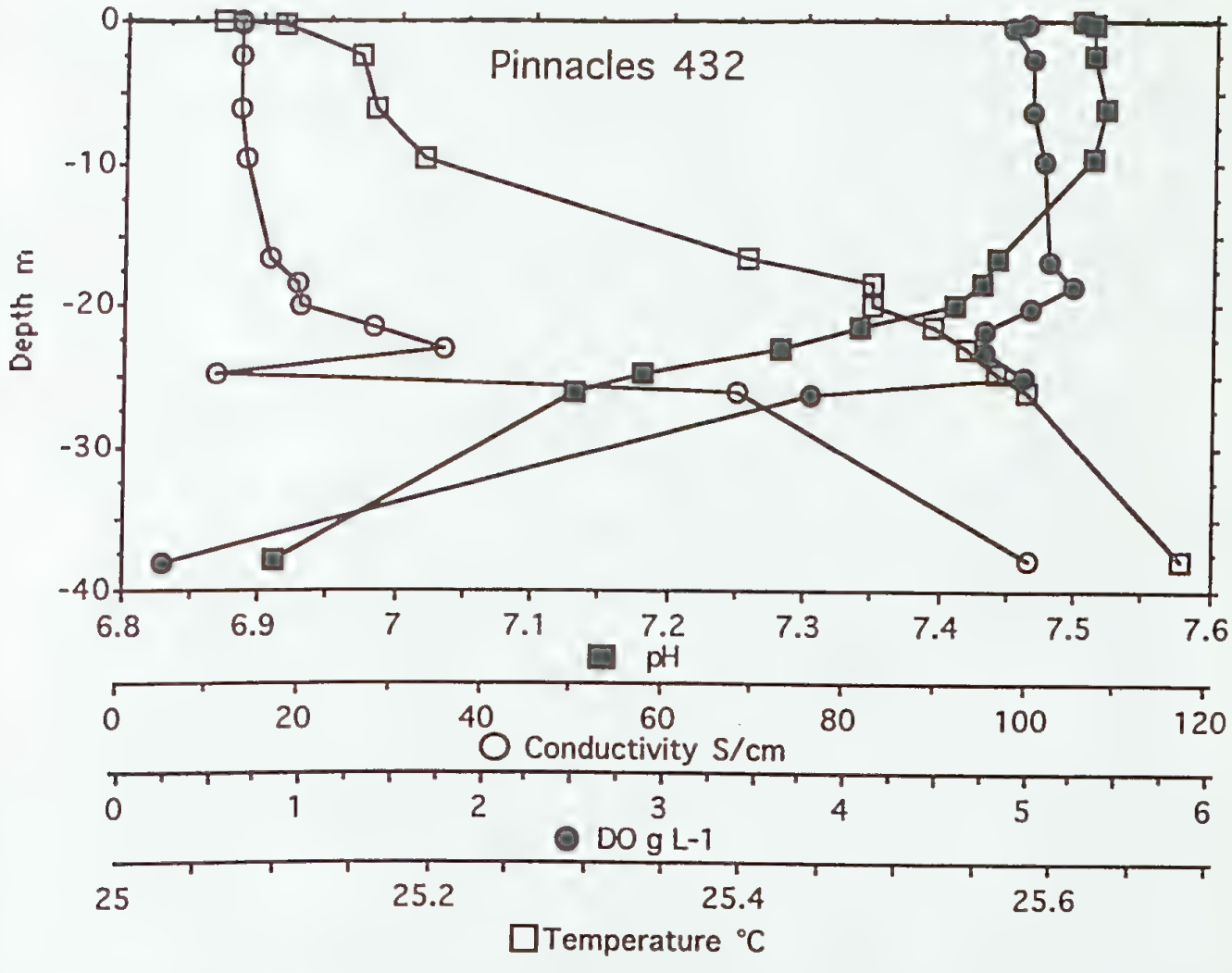


FIGURE 152. Distribution of physicochemical profiles at the Pinnacles, the type locality of *Nirripirti fortisspina* sp. nov.

the physicochemical environment within the calcrete aquifers appear to be quite heterogeneous, both within the groundwater profile and between areas (Figs 152, 153). For example, closely adjacent bores may yield consistently different faunas and have different water quality and profiles (Table 4; Fig. 153). Conversely, waters with different DO profiles may have rather similar faunas and provide no clear relationship between DO concentration and stygofauna (Table 5; Fig. 155). Interpretation of such trends requires a more detailed knowledge of water quality and particularly of the section(s) of the profiles inhabited by the various stygobites. It is possible that attributes other than water quality, in a physicochemical sense, are the determinants of suitability for stygofauna; microbiological characteristics appear to be important determinants of the presence of stygofauna in some German aquifers (H.J. Hahn, pers. comm., 2002).

ACKNOWLEDGMENTS

We appreciate assistance in the field from J. Waldock, R. Read, A. Russ, T. Karanovic, S. Cooper and G. Watts. Numerous pastoralists and mining companies and their staff provided invaluable information and access. Field work in the Northern Territory was enabled by P. Jolly, and material support was received from the Water Resources Division, Department of Lands Planning and Environment, Northern Territory. R. Read provided planning and logistical support and he and A. Russ accompanied the fieldwork. K. Mc Phail is thanked for cleaning up late drafts of the manuscript.

We would particularly like to thank H. Hamon for the illustrations and for help in setting out the figures.

This work was supported by funds from the Australian Biological Resources Study.

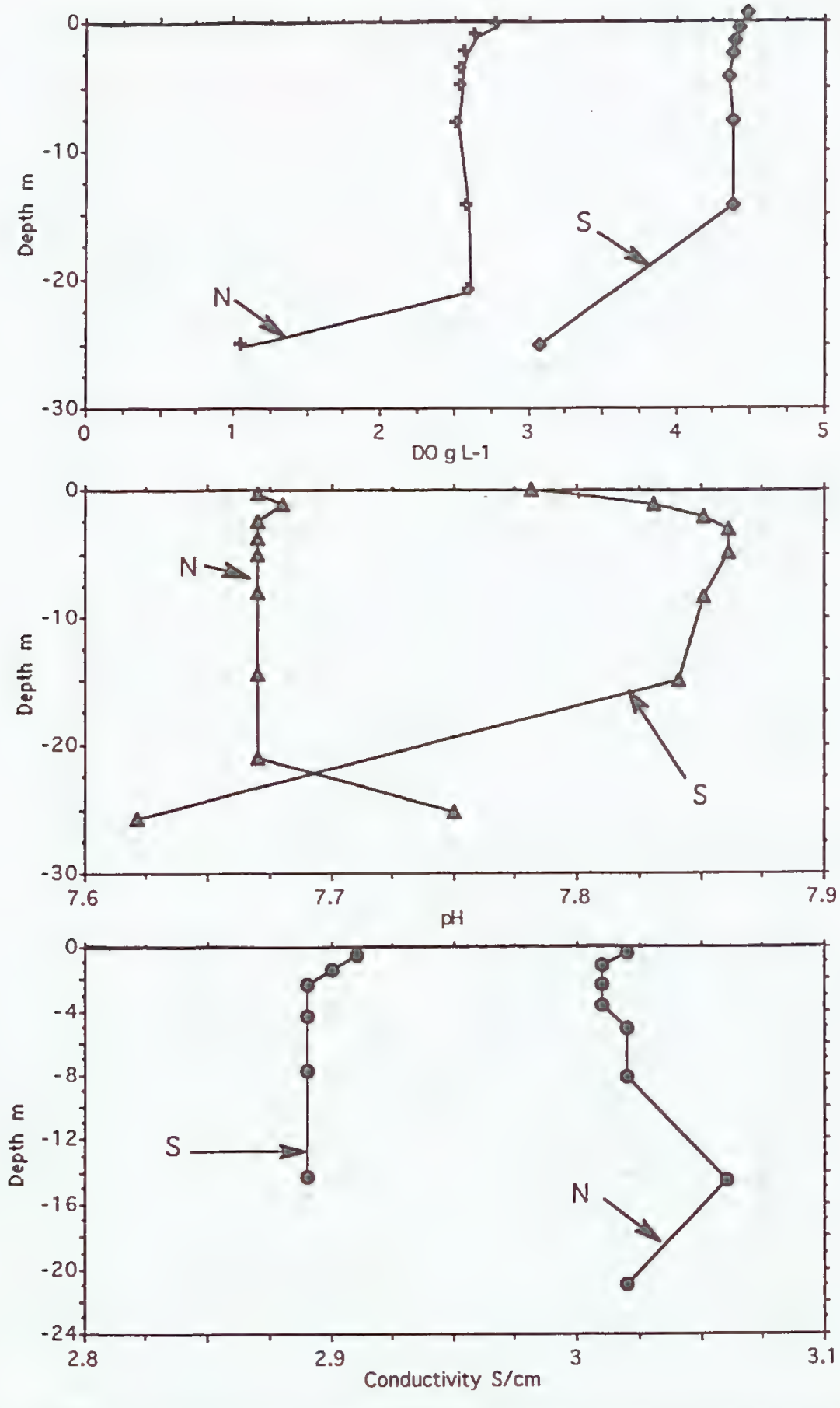


FIGURE 153. Profiles of physicochemical parameters through the water column of bores in the Hinkler calcrete (Table 4). The two bores, denoted N (north) and S (south), were drilled for the Main Roads Department at the same time to supply water and are less than 30 m apart. They have consistently yielded different fauna, even before they were used for water abstraction.

TABLE 4. The distribution of taxa between the two adjacent bores depicted in Fig. 153

Taxon	North	South
Amphipoda	4	3
Bathynellacea	98	431
Dytiscidae	99	5
Copepoda	20	0

TABLE 5. The distribution of taxa between bores in the Lake Violet area, depicted in Fig. 155

Taxon	Pump 1	OB 3	OB 4	OB 5	OB1
Ostracoda	255	–	–	9	66
Amphipoda	16	–	15	–	12
Bathynellacea	2	1	1	2	3
Dytiscidae	8	–	1	–	13
Copepoda	9	3	4	27	47

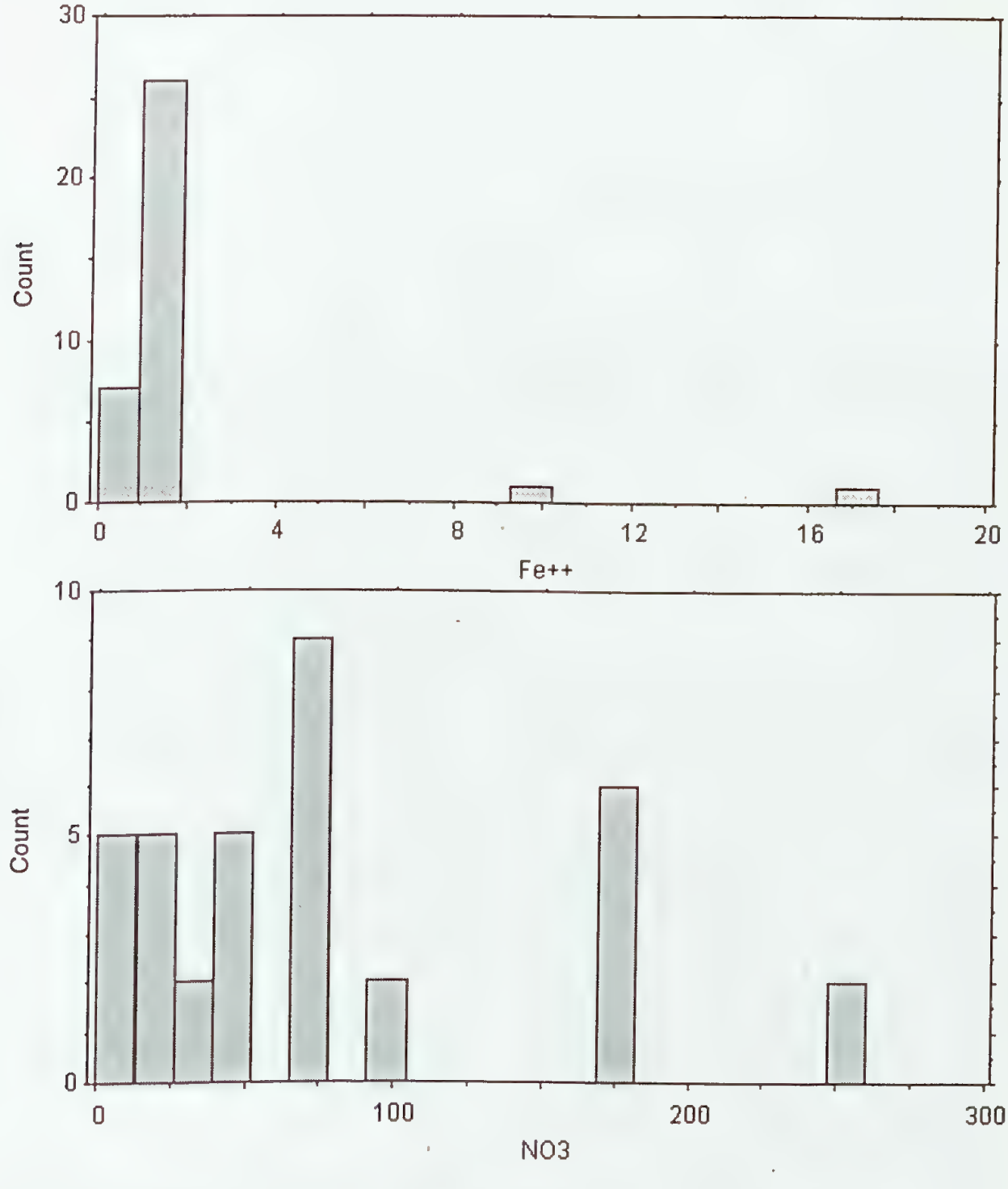


FIGURE 154. Distribution of iron (II) and nitrate in water samples from the Yilgarn groundwater calcrete samples. Upper: iron (II) (mg L^{-1} Fe^{++}) and lower: nitrate (mg L^{-1} nitrate)

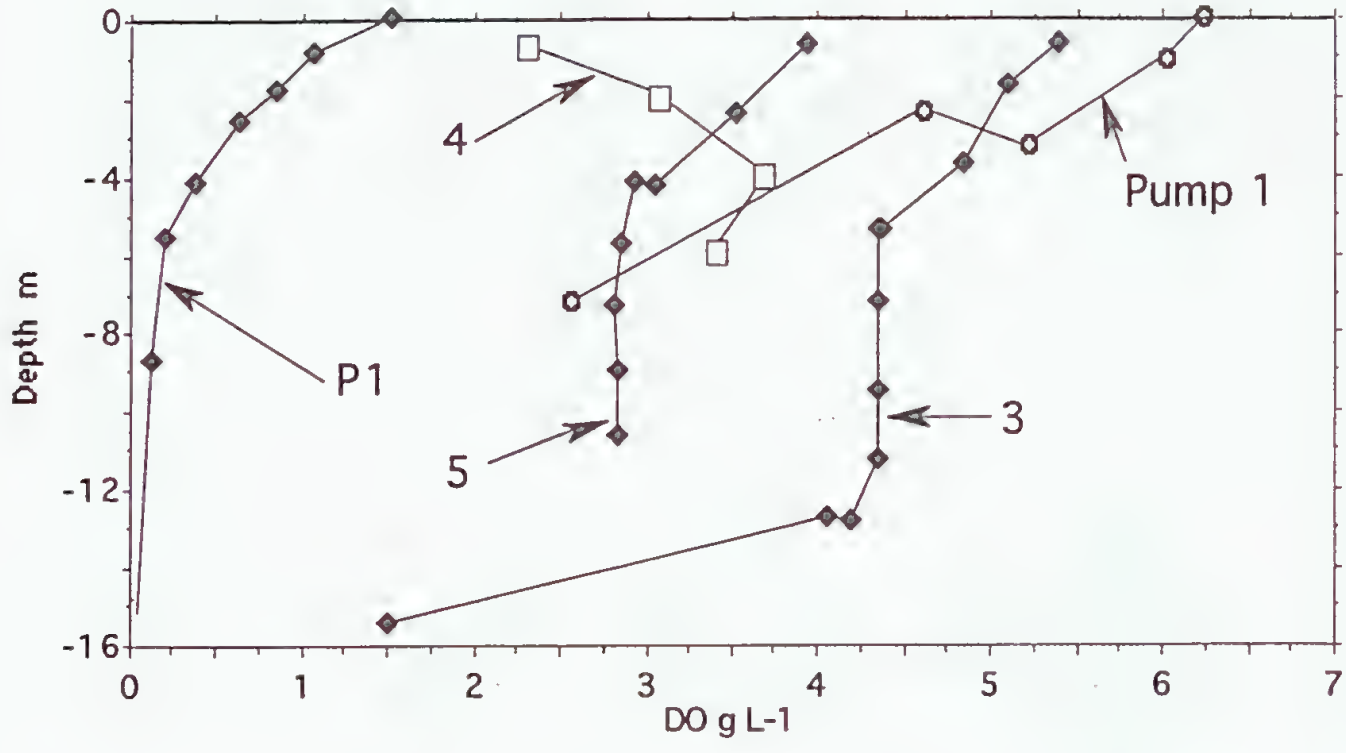


FIGURE 155. The vertical distribution of oxygen in the Lake Violet borefield area, an area of major water abstraction and the type area for *Tjirtudessus wilunaensis* sp. nov. The profiles are all from monitoring bores closely adjacent to an actively pumping well-field. P1 is the observation bore (OB1) for Pump 1 as denoted in Table 5.

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PROVISIONAL CHECKLIST OF THE ASILIDAE (INSECTA: DIPTERA) OF SOUTH AUSTRALIA, UTILISING AN UPDATED SUBFAMILY CLASSIFICATION

ROBERT J LAVIGNE

LAVIGNE, RJ. 2003. Provisional checklist of the Asilidae (Insecta: Diptera) of South Australia, utilising an updated subfamily classification. *Records of the South Australian Museum* **36**(2): 189–194

A provisional checklist of the Asilidae (robber flies) of South Australia is provided. Distribution notes for individual species are provided, where available. The higher classification of the Asilidae, as found in South Australia, is updated.

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The purpose of this paper is threefold: a) to provide currently known distributions of South Australian robber flies (Insecta: Diptera: Asilidae), as recorded in the published literature, and to add to distributions of these predatory flies; b) to provide citations for biological/behavioural information for these same robber flies, where available; and c) to update the classification of South Australian Asilidae in line with recent changes in subfamily classification.

Little is known of the distribution of South Australian robber flies. The first published reference dealing with species from South Australia (SA) appeared in the second volume of the *Transactions and Proceedings and Report of the Philosophical Society of Adelaide, South Australia for 1878-9*. In that volume Otto Tepper (1879) wrote as follows: "The Asilidae and their near allies comprise nineteen species, including the giants of the order, which inhabit Yorke's Peninsula and adjacent parts, and measure one and three quarter inches in length. All are carnivorous." Undoubtedly, he was referring to members of the genus *Phellus*, which are the largest known asilids. Unfortunately, no individual species were listed.

During the 1950s Frank M Hull, author of the two volume definitive work on the asilid genera of the world, visited the SA Museum (SAM). As a result of his visit, he described several species of *Bathypogon* (Hull 1958a, b, c, d, 1959), with the types of the following species being deposited in the SA Museum: *bidentatus* (Holotype), *calabyi* (Holotype), *douglassi* (Holotype), *flavifemoratus* (Holotype), *ichthyurus* (Holotype), *macrodonturus* (Holotype), *nigrotibiatus* (Holotype), *ochraceus* (Holotype, Allotype, Paratype), *ophiurus* (Holotype), *robustus* (Paratype), *rubidapex* (Paratype), *rufitarsus* (Holotype, Allotype). However, only five of these species were described from South Australian specimens: *calabyi*, *ichthyurus*, *ochraceus*, *ophiurus* and *rufitarsus*.

In his extensive taxonomic revision of the widespread Australian tribe Chrysopogonini, Clements (1985) was only able to record seven species (out of 49, representing four genera) as occurring in South Australia. Clements (pers. comm.), however, did not access the SA Museum collection. Similarly, Daniels (1987), in his revision of *Neoaratus* Ricardo with descriptions of six allied new genera (58 species), recorded only four species from South Australia.

In 1989 Daniels published the Family Asilidae, as part of the Catalog of the Diptera of Australasia and Oceanic Regions, a version of which may be accessed on the internet (<http// :hbs.bishopmuseum.org/aocat/asilidae.html>). In it he recorded 36 species from South Australia, without, however, providing data on their distribution or indicating the basis for noting their occurrence in SA. A search of the SA Museum collection in July–August 2002 failed to reveal any specimens other than types which had been identified by Daniels. Subsequently, in September 2002, a visit was made to Melbourne to examine Daniels's extensive personal asilid collection to see if it contained specimens from South

Australia, other than the collection made by RJ Lavigne in 1978–79 which is contained therein. During the visit, it was determined that much of the material noted as occurring in South Australia had been loaned to Daniels by the SA Museum. Specimens had been identified, data recorded and the specimens returned without identity labels. This has now been rectified. Daniels kindly provided access to his ledger and database so that I might obtain SA records. It should be noted however that, because of the infant state of Australian asilid taxonomy, many of the SA specimens in his collection were only identified to genus. Consequently, only data dealing with identified species has been incorporated into this preliminary checklist.

Little has been accomplished in enumerating the biology/behaviour of South Australian Asilids. A start was made by Lavigne (1982a,b, 1984, 1992) in which the behaviour of three species of *Cerdistus*, a species of *Neoscleropogon*, a species of *Neocerdistus*, two species of *Colepia* and a species of *Mauropteron* were described, but nothing more has since been published.

The classification of asilid subfamilies used in this paper is an interim one based upon the recent published works of Papavero (1973), Artigas & Papavero (1988), and Lehr (2001). As pointed out by Fisher and Wilcox (unpublished), such a classification scheme provides a more uniform system and appears to be a distinct improvement over previous classification schemes. It is obvious to many systematists that all available classifications of Asilidae are flawed (principally by a general lack of rigorous phylogenetic analysis): and that it is to be expected that many changes will be made as a result of future studies.

In 1878–79 only four subfamilies were recognised: Asilinae, Dasypogoninae, Laphriinae and Leptogastrinae (Tillyard 1926). Daniels (1989) still only recognised the same four subfamilies as occurring in the Australasian and Oceanic region. Over the years the higher taxonomy of the Asilidae has evolved considerably, with new families being established or tribes (as used by Daniels 1989) being elevated to the status of subfamily, representatives of ten of which are known to occur in Australia: Apocleinae (Papavero 1973), Atomosiini to Atomosiinae (Lehr 1977), Dioctriini to Dioctriinae (Lehr 2001), Laphystini to Laphystinae (Papavero 1973), Ommatiini to Ommatiinae (Ricardo 1929), Stenopogonini to Stenopogoninae (Paramonov 1966) and Stichopogonini to Stichopogoninae (Artigas & Papavero 1988).

Worldwide, 13 subfamilies are now considered valid by many authors: Apocleinae, Asilinae, Atomosiinae, Dasypogoninae, Dioctriinae, Laphriinae, Laphystinae, Leptogastrinae, Megapodinae, Ommatiinae, Stenopogoninae, Stichopogoninae and Trigonominae.

The following checklist contains data on 52 species, representing 6 subfamilies and 21 genera, the names of which have appeared in the published literature over the last 123 years. On the basis of this census, there has been an increase of, at least, 33 named species in South Australia since Tepper's original paper; however, it is unclear how many species Tepper considered to be robber flies and how many to be carnivorous allies of the Asilidae. This listing by no means represents the total number of asilid species to be found in South Australia, but stands as a base for an enlarged checklist that will be based on material being currently identified and stored in the SAM insect collection, as well as material that is being acquired by survey teams. Daniels (pers. comm. 2002) has suggested that, based on his studies, there are well over 100 undescribed species of *Bathypogon* alone, Australia-wide.

Within the checklist are included notations of SA specimens identified by Daniels but which are deposited in other museums. These abbreviations used are as follows: AM – Australian Museum, Sydney; ANIC – Australian National Insect Collection, Canberra; BMNH – British Museum of Natural History; GDC – Greg Daniels Collection; OX – Oxford University (Hope Collections); WARI – Waite Agricultural Research Institute, Adelaide.

Checklist

Apocleinae

Blepharotes coriarius Wiedemann, 1830 [Daniels 1989] [Daniels, pers. comm.: Adelaide (WARI). 25 Jan]

Blepharotes flavus Ricardo, 1913b [Daniels 1989] [Daniels, pers. comm.: Adelaide; Parakalyia Bore, Everard Pk. Stn., Port Lincoln. 2 Nov]

Asilinae

Asiola lemniscata Daniels, 1977 [Daniels 1989] [Daniels 1977: 48. Paratypes: Immarna; Kimba; Nundroo (Homestead), 5 mi W. 20–28 Oct] [Daniels, pers. comm.: Maya, 2 mi S.]

Cerdistus armatus (Macquart, 1846) [Lavigne 1982a (ethology, as *Neoitamus armatus*)]

[Lavigne 1982a: 625. Aldinga Beach; Ferries-McDonald Conservation Park, S of Monarto. 11 Dec – 31 Jan]

Cerdistus exilis (Macquart, 1838) [Hardy 1935b (as *Asilus exilis*): 415. Kangaroo Isl. (South Australia)] [Daniels 1989]

Cerdistus margitis (Walker, 1849) [Lavigne 1982a (ethology, as *Neoitamus margites*)]

[Lavigne 1982a: 625. Ferries-McDonald Conservation Park, S of Monarto; Mortlock Exp. Stn., Auburn; 3.3 km S of Echunga; 8 km ENE of Callington. 11 Dec – 1 Mar. Lavigne 1982a]

Cerdistus neoclaripes Hardy, 1921 [Hardy 1935b (as *Neoitamus neoclaripes*): 415. "South Australia", no date] [Daniels 1989]

Cerdistus rufometatarsus (Macquart, 1855) [Hardy 1935b (as *Asilus rufometatarsus*); 416. Adelaide (South Aust.), no date] [Daniels 1989]

Cerdistus rusticanoides Hardy, 1926 [Hardy 1935b: 410. "South Australia", no date] [Daniels 1989]

Cerdistus setifemoratus (Macquart, 1855) [Daniels 1989]

Cerdistus vittipes (Macquart, 1847) [Lavigne 1982a (ethology, as *Neoitamus vittipes*)] [Lavigne 1982a: 617–18. Adelaide; Keyneton, 4.5 km E; Kapunda, 2.7 km S, bank of Light River; Kingston, 16 km N; Milang, 12 km SE, 3 & 8 km E, 10 km S; Morgan, 11.6 km NW; Port Gawler; Port Wakefield. 23 Nov – 27 Mar] [Daniels, pers. comm.: Adelaide (GDC); Virginia, ca. 6 km SW. 25 Nov – 1 Feb]

Colepia abludo Daniels, 1983 [Daniels 1983 (as *Neoaratus abludo*): 233. Aldinga, 8.2 km S; Aldinga Beach; Elizabeth; Hammond; Lyndoch; Mortlock Exp. Station, Auburn. 30 Dec – 24 Jan] [Lavigne 1992 (ethology, as *Neoaratus abludo*); Lawson & Lavigne 1984 (description of eggs)] [Daniels 1989 (as *Colepia*)]

Colepia ingloria (Macleay, 1826) [Hardy 1935a (as *Neoaratus ingloria*): 182. "South Australia", no date] [Daniels 1987 (biology, pupal description)]

Colepia rufiventris (Macquart, 1838) [Hardy 1935a (as *Neoaratus rufiventris*): 185. "South Australia", no date] [Daniels 1987 (biology, pupal description); Daniels 1989; Lavigne 1992 (ethology, as *Neoaratus rufiventris*)] [Daniels 1987: 500. Belair; Blackwood; Bridgewater; Engelbrook Reserve; Ferries-McDonald Conservation Park; Hawthorndene; Lobethal; Paracombe; Tailem Bend; Tooborang, nr. Adelaide; Victory; Waitpinga, no dates] [Lavigne 1992: 261. Kingston, 16 km N, opp. Coorong Game Reserve; Mt Barker. 18 Dec – 2 Mar] [Daniels, pers. comm.: 1 Jan – 7 Mar]

Mauropteron pelago Daniels, 1987 [Ricardo 1913b (as *Asilus pelago*): 443. Adelaide, no date] [Hardy 1935a (as *Neoaratus pelago*): 186. "South Australia", no date] [Daniels 1987 (biology): 510. Adelaide; Balgowan, 4 km NE, nr. Maitland; Benif Station, Coorong; Ferries-McDonald Conservation Park; Flinders Isl.; Iron Baron; Kingston, South-East; Lowan Station, 4 mi S of Sherlock; Port Lincoln; Purnong, nr. Murray Bridge; Seal Bay, Kangaroo Isl.; Sedan, 5 km W; Sleaford Bay; Whyalla; Winceby Isl., no dates] [Daniels 1989] [Lavigne 1992 (ethology, as *Neoaratus pelago*): 261. Ferries-McDonald Conservation Park; Sedan, 5 km W. 4 Dec – 5 Feb] [Daniels, pers. comm.: Kimba, 32 km E; Nullarbor. 4 Dec – 4 Apr]

Neoaratus hercules (Wiedemann, 1828) [Daniels 1987 (biology, pupal description) : 513 [Castle Hill, Kangaroo Isl.; Fleurieu Peninsula; Kingscote, Kangaroo Isl.; Mt Lofty; Reedy Creek, SE South Aust.; Tanunda, Upper Sturt; Adelaide, no dates] [Daniels 1989] [Daniels, pers. comm.: Norton Summit, nr Ashton; Westridge (ANIC). 18 Nov – 21 Jan]

Neocerdistus acutangulatus (Macquart, 1847) [Lavigne 1984: 422. One Tree Hill, E of Elizabeth, nr. Para Wirra National Park. 5 – 30 Apr] [Lavigne 1984 (ethology); Daniels 1989]

Neoitamus mistipes (Macquart, 1850) [Ricardo 1913b: 433. Mt. Gambier, S. Australia, no date] [Daniels, pers. comm.: Mt Compass, Cox's Scrub Nat. Pk., 12 km SE. 20 Jan]

Dasypogoninae

Apothechyla carbo (Walker, 1851) [Hardy 1934b (as *Rachiopogon carbo*): 23. "South Australia", no date]

Brachyrhopala (*Brachyrhopala*) *quadricincta* Bigot, 1879 [Clements 2000: 87. Horrocks Pass, SE of Port Augusta, no date]

Chryseutria amphibola Clements, 1985 [Clements 1985: 82. Holotype ♀, Paratype ♀, Emu Field, 300 mi NW of Woomera. Sept – Oct 1953] [Daniels 1989]

Chrysopogon agilis Clements, 1985 [Clements 1985: 8. "S Australia"] [Daniels 1989]

Chrysopogon albosetosus Clements, 1985 [Clements 1985: 21. Mt Serle, Flinders Ranges, no date] [Daniels 1989]

Chrysopogon castaneus Clements, 1985 [Clements 1985: 29. "S. Aust.", no date] [Daniels 1989]

Chrysopogon pellos Clements, 1985 [Clements 1985: 58. Holotype ♂, Marla Bore, 30 mi W of Melbourne Hills Homestead. 23 Mar] [Daniels 1989]

Chrysopogon pilosifacies Clements, 1985 [Clements 1985: 60. Koonalda, 14 mi E. 17 Oct] [Daniels, pers. comm.: Fisher E-W Line (AM); Port Augusta, SE of Horrocks Pass. 21 Nov] [Daniels 1989]

Chrysopogon rubidipennis White, 1918 [Clements 1985: 65 [SA "no locality"] [Daniels 1989]

Chrysopogon trianguliferus Clements, 1985 [Clements 1985: 72. Curnamona Station, Yunta Highway, 7 mi N turn to Erudina Woolshed, Wirrealpa Station, 1 km N Marshals Corner Bore. 17 – 19 Feb] [Daniels 1989]

Dakinomyia froggattii Dakin & Fordham, 1922 [Daniels, pers. comm.: Nullarbor roadhouse, 183 km W. 23 Jan] [Daniels 1989]

Questopogon affinis Daniels, 1976 [Daniels, 1976: 229. Kimba, no date, E. Broomhead, Paratype ♀ [Daniels 1989]

Thereutria amaraca (Walker, 1849) [Daniels 1989] [Daniels, pers. comm.: Wilpena Pound, Flinders Range. 19 – 20 Jan]

Thereutria tessellata (Hardy, 1930) [Daniels 1989] [Daniels, pers. comm.: Milang; Wilpena Pound, Flinders Range. 8 – 19 Jan]

Laphriinae

Laphria rufifemorata Macquart, 1846 [Ricardo 1913a: 155. Bakewell, "S. Australia", no date] [Hardy 1934a: 520. "South Australia", no date]

Laphria telecles Walker, 1849 [Daniels, pers. comm.: Ravine des Cas., Kangaroo Isl. 30 Nov]

Ommatiinae

Ommatius distinctus Ricardo, 1918 [Daniels, pers. comm.: Flinders Isl., northern Arkaroola. 22 Jan]

Ommatius pilosus White, 1916 [Daniels 1989] [Daniels, pers. comm.: Mortlock Exp. Stn., Auburn; Mt Lofty Botanical Gardens. 17 – 31 Jan]

Ommatius queenslandi Ricardo, 1913 [Daniels, pers. comm.: Wilpena Pound, Flinders Range. 19 Jan]

Stenopogoninae

Amphisbetetus trinotatus Paramonov, 1966 [Daniels 1989] [Daniels, pers. comm.: Kalabity H.S., Birthday Rd, 5.6 km N. 15 Feb]

Bathypogon aoris (Walker, 1849) [Ricardo 1912: 153. Adelaide (Ent Club) (type female), no date] [Hardy 1934b: 9. "South Australia", no date. (after Ricardo 1912)] [Daniels 1989] [Daniels, pers. comm.: Adelaide (BMNH)]

Bathypogon calabyi Hull, 1958 [Hull 1958a: 199. Owieandana, N. Flinders Range. Holotype ♂] [Daniels 1989]

Bathypogon chionthrix Hull, 1958 [Hull 1958c : 161. Kalamunda, no. date. Holotype ♂, Allotype ♀] [Daniels 1989] [Daniels, pers. comm.: Kimba, 32 km E. 21 Jan.]

Bathypogon ichthyurus Hull, 1958 [Hull 1958d: 187. L. Callabonna, no date. Holotype ♂] [Daniels 1989] [Daniels, Pers. Comm.: Lk. Callabonna, no date]

Bathypogon microdonturus Hull, 1958 [Hull 1958d: 190. Owieandana, N. Flinders Range, no date. Holotype ♂] [Daniels 1989]

Bathypogon ochraceus Hull, 1959 [Hull 1959: 18: Owieandana, N. Flinders R, no date. Holotype ♂, Allotype ♀, 4 Paratypes]; Daniels 1989]

Bathypogon ophiurus Hull, 1958 [Hull 1958b: 62. Flinders Isl., no date. Holotype ♂] [Daniels 1989] [Daniels, pers. comm.: Flinders Isl., no date]

Bathypogon rufitarsus Hull, 1958 [Hull 1958b: 64.] Mt Serle, N. Flinders Range. Holotype ♂, Allotype ♀] [Daniels 1989] [Daniels, pers. comm.: Keyneton, 6.4 km E; Monarto; Mt Serle, Flinders Range; Port Wakefield; Virginia, ca. 6 km SW. 23 Nov – 11 Dec]

Bathypogon testaceovittatus (Macquart, 1855) [Hardy 1934b: 8. Adelaide, South Australia] [Daniels 1989] [Daniels, pers. comm.: Adelaide (OX)]

Neoscleropogon agave (Walker, 1849) [Hardy 1928 (as *Stenopogon agave*), Hardy 1934b (as *Stenopogon agave*): 15. "South Australia"

Neoscleropogon durvillei (Macquart, 1838) [Daniels, pers. comm.: Port MacDonnell. 6 Jan]

Neoscleropogon lanatus (Walker, 1849) [Hardy 1928 (as *Stenopogon lanatus*), Hardy 1934b (as *Stenopogon lanatus*): 14. "South Australia"]

Neoscleropogon macquarti Daniels, 1989 [Ricardo 1912 (as *Neoscleropogon elongatus*): 156. "S. Australia"] [Lavigne 1982b, as *Neoscleropogon elongatus* (ethology)] [Lavigne 1982b: 742–43. Aldinga Beach; Ferries-McDonald Conservation Park, south of Monarto; Sandy Creek, nr Gawler. 28 Nov – 22 Jan]

Phellus piliferus Dakin & Fordham, 1922 [Barker & Inns 1976 (ethology); Daniels 1989] [Daniels, pers. comm.: Hambridge Consv. Pk., western boundary; Renmark, 30 mi NNW; Sleaford Bay, Port Lincoln. 23 Jan – 1 Mar]

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